SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • February 24, 1959

Some tips on trips

A field trip *can* be a potent learning experience for students and a gratifying experience for the teacher. It can also be a waste of time and money for students and an exasperating ordeal for the teacher. Which it is depends on how wisely the place to be visited is selected, how meticulously the details of the trip are planned, and how well the plans are carried out. The purpose of this article is to offer some suggestions for planning a satisfying trip.

Selecting the place to be visited. The alert teacher will find any number of out-of-school places that offer opportunities for science learning. To name a few: museums, zoological parks, botanical gardens, chemical and other industrial plants, airports, telephone buildings, radio and TV stations, power plants, engineering projects, farms, gardens (even vacant lots), woods, fish hatcheries, tree nurseries, mines and quarries, lake or ocean shorelines, caves, gaps, exposed rocks, ponds, lakes, streams, bogs, greenhouses, departments of health and sanitation, water purification plants, sewage disposal plants, milk pasteurization plants, hospital laboratories.

Select the trip with a definite purpose in mind, and relate the trip to a unit or topic in your course of study. Your purpose may be to introduce a unit of work, to bring a unit to culmination, or to provide a learning experience as an integral part of a topic you are teaching. You may even make a trip to introduce your course of study. I often begin my biology course with a field trip for the class to find out how many forms of life exist in the vicinity of our school building, which is located in a very much citified area. I am always amazed at how many forms of life are turned up by thirty pairs of eyes — a nest of sparrows over a store awning, mosses on stone walls, ants in the crack of a sidewalk, a ball of baby spiders under an iron gate, and many other such finds.

If the place is at some distance from the school, consider the means of transportation that are available. Be sure the place can accommodate the size of the group you plan to take.

First take the trip yourself. Take careful notes of the specific experiences the trip makes possible. For example: What natural phenomena can the students observe? What apparatus can they see in use? What scientific methods can they see applied? What vocational opportunities can they be led to explore? What student activities can be stimulated as a follow-up of the trip?

Do not overlook incidental experiences. When your students visit a laboratory, it is good for them to see that scientists do more than tinker and observe — they take notes and they depend on books and journals. Even the fact that one scientist is away may be significant if the information is supplied that he is visiting a consultant, attending a meeting, or working in the field. It is good for students to see that some scientists are young and that some are women — and attractive, at that.

Having made note of all these things, select a number of unified experiences that may be set up as the trip's major objective and a set of incidental objectives. The major objective should be in terms of "to find out" or "to see." For example, a chemistry class visiting a paper mill might have as its major objective to find out how chemistry is applied in the manufacture of paper. A biology class visiting a sewage disposal plant might have as its major objective to find out how favorable conditions are provided for micro-organisms to purify water. A physics class visiting a factory might go to see how transformers are constructed and tested. A general science class visiting the boiler room of the school building might go to find out how heat is efficiently produced and transported.

Plan the arrangements. Establish your transportation route. If you are to visit an institution, fix and confirm the date and time of the trip. Ascertain the name of the person who is to meet your class and the exact spot where he is to be met. Agree on the divisions of your class and on the routes through the laboratories or plant that are to be taken by the groups. If the trip is to be extended beyond noon, make arrangements for lunch. If the trip is to the outdoors, give instructions on what to do if it rains. Choose a place of meeting for departure and a point from which the class will be dismissed to go home. Above all, be sure you obtain parent-consent in writing. For this purpose permission-forms are recommended because through such a form the parent is sure to obtain essential information. Before he gives his consent, a parent is entitled to know the date and time of the trip, its duration, the place of meeting, the nature of the activity — especially if it is out-of-doors — the name of the teacher who will be in charge, the cost, and the time and place of dismissal.

Prepare your students for the experience. "Motivate" a trip as you do a lesson. Try to stimulate a need or desire to go to the place you have selected. For example, in the case of the paper mill, you might ask the chemistry class, "What changes would a log have to undergo before it could become a sheet of writing paper?" After some discussion, you might ask, "Where might we actually see these changes being brought about?" In the case of the sewage disposal plant you might confront the biology class with this statement: "Micro-organisms pollute water and micro-organisms purify water." This can stimulate a discussion

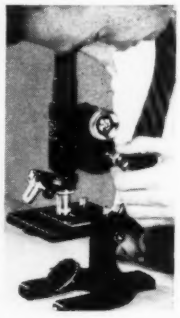
[*Continued on p. 5-T*]

AO Reports on Teaching with the Microscope

Sanguinary explorations among the monocytes and neutrophiles... or narcism in the classroom.

Someone of sublime wisdom (Schopenhauer, we think) once said that, "things in general become absorbingly interesting when related specifically to ourselves". With this in mind we herein offer a teaching experiment on the observation of red and white blood cells which provides an elementary excursion into the mysteries of the human blood stream.

The basic technique given here for obtaining blood and making stained smears is used by trained clinical laboratory technicians and physicians seeking vital diagnostic information. Used in your classroom, it can bring real drama as your students study their own blood.



You'll need good microscopes for this experiment... scopes with the qualities of a professional clinical laboratory instrument. Our 66 series microscope, with excellent image quality, precise fine adjustment and ruggedness, is ideal.

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EXPERIMENT

Observation of Red and White Blood Cells

MATERIALS AND PREPARATIONS

Blood lancet or sharp needle; 2″ x 2″ gauze squares; 70% alcohol; microscope slides and cover glasses; vaseline; Wright's Stain (inexpensively obtainable as a ready-to-use solution from any laboratory supply house); distilled water; normal saline; medicine dropper; AO Spencer No. 66 compound microscope equipped with 10X, 43X objectives and 10X eyepiece (oil immersion 97X objective would be ideal).

Set up microscope; clean several slides with acetone and polish dry with clean cloth; rim a cover glass with vaseline; sterilize lancet or needle over flame and place in 70% alcohol.

PROCEDURE

1. Scrub middle finger of willing student "patient" with gauze soaked in 70% alcohol. Wipe dry. Grasp finger between thumb and index finger and squeeze down toward tip; a slight prick with a needle or lancet will yield abundant blood which should form in firm drops if finger is absolutely dry. (Fig. A)

Fig. A

2. Place drop of blood on end of one slide and touch end of second slide to it (see Fig. B) at an acute angle... push second slide over first to make thin blood smear. Make several slides and allow to dry.

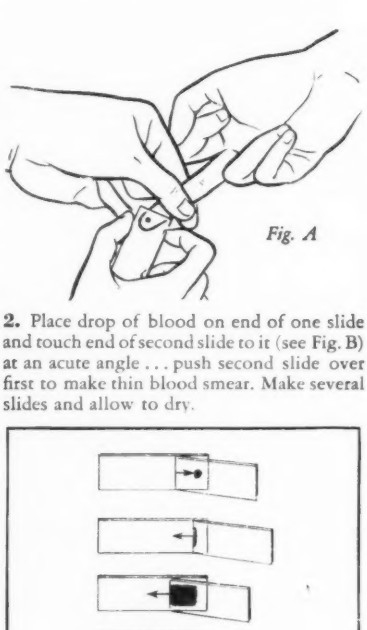

Fig. B

a. *Observation of whole red blood cells:* While smears are drying, place another drop of blood on clean slide... add drop of normal saline and place vaseline rimmed cover glass over mixture. Press until thin film forms and vaseline makes air-tight seal. Observe under 10X and then 43X... whole red blood cells can be seen suspended in the plasma-saline solution. (Fig. C)

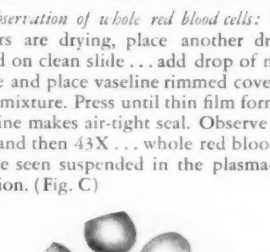

Fig. C

Red blood cells

b. *Differential staining of white blood cells:* Place dry smear on rubber stopper (stain in sink or disposable catch pan, i.e. made of aluminum foil). With dropper, cover slide with 30 drops of Wright's stain, allow to fix for 1 minute... add 30 drops of distilled water. Blow gently on mixture until metallic film forms. Let stand 4-5 minutes, then flood stain off with tap water. Blot dry and observe under microscope. Locate thin edge of smear with 10X and then switch to 43X (oil immersion, 97X is preferable). Red blood cells will appear a faded pink or orange color. The different kinds of white blood cells will be stained in varying shades of purplish-blue and eosin, a yellowish-orange color; pebbly clumps of platelets (necessary factor in blood-clotting) will be stained a pale blue. (Fig. D) Under oil immersion, and even under 43X, the various white blood cells can be easily differentiated as polymorphonuclears, segmented neutrophiles, monocytes, etc., by differences in nuclei, cell sizes and staining characteristics. (See Kracke and Garver: *Diseases of the Blood and Atlas of Hematology* for color plates of actual white blood cells differentially stained).

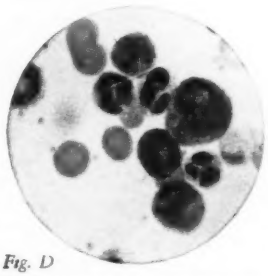

Fig. D

White blood cells from stained smear

c. *Importance of differential white blood counts.* During the course of a disease, the total white blood cell count increases or decreases. However, the doctor must also know the *type* of cell involved. For example, a high white blood cell count with a preponderance of lymphocytes indicates the possibility of mumps, whooping cough, German measles or leukemia. A large number of neutrophilic cells indicates possible rheumatic fever, localized acute infection, or scarlet fever.

OBJECTIVES: This elementary hematological experiment achieves these science objectives: a fund of knowledge about the human body and the physiology of blood; skill in the use of the compound microscope and an appreciation of its application to medicine; clinical laboratory techniques and their diagnostic importance.

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MEMO

To: Science teachers

Subject: Ways to use this issue of SCIENCE WORLD in the classroom

The invisible universe

PHYSICS TOPIC: electromagnetic waves — their history and modern applications

GENERAL SCIENCE TOPICS: radio-astronomy, cosmology, the sun, the planets, an application of artificial earth satellites

This is yet another saga of how man is overcoming his blindness to things that have existed in his world since time immemorial and of which he has been totally ignorant. Through giant ears — 250 feet in diameter — he listens to a wondrous heavenly cacophony whose meaning he is trying to unravel. He listens to the sun and to the planets Venus and Jupiter. The "music" reveals information about them that he never suspected — information about conditions hidden under their surfaces. Even the moon and Mars sing into his giant parabolic bowls. Some day these giant ears will be put out into space for further exploration of our mysterious universe.

Questions

1. What discovery, leading to the development of modern radio-astronomy, was made by each of these scientists: Maxwell, Hertz, Jansky?
2. How do a radio-telescope and a light-telescope compare?
3. Why does it take experts to interpret radio-telescope information?
4. How may the study of the sun by means of radio-telescopes transform life here on earth?
5. What does the radio-telescope reveal concerning Venus, Mars, Jupiter, the moon?
6. What are "radio-stars"?
7. What is the interpretation of the huge surge of radio waves that comes from the region of Cygnus?
8. What would be some of the advantages of installing radio-telescopes on artificial satellites in outer space?

Student activities

Students can experience the effects of electromagnetic waves as follows:

In school, operate a spark coil while an AM radio receiver is on. Ground one terminal of the spark coil by connecting it to a water pipe. Set up a spark gap between two pieces of copper wire connected to the secondary of the spark coil. To the other terminal, connect a small metal plate in an upright position. Note the effect on the "static."

At home, note the effects on an AM radio or on a television screen when a motor-driven device such as an egg beater or a vacuum cleaner is turned on. If you have a short-wave radio, turn the dial slowly, and see if you can interpret the sounds you hear.

Vaccines to fight viruses

BIOLOGY TOPICS: infectious diseases, immunization, tissue culture

GENERAL SCIENCE TOPIC: preventing and fighting disease

The biology teacher will find this article useful for introducing students to the field of virology and some of its applications in disease prevention. While the recently developed Salk polio vaccine furnishes a dramatic example of scientific accomplishment in this field, the article points to frontiers of current research. These promise equally dramatic results and pose a challenge and an invitation to the interested and gifted biology student. The illustrated descriptions of methods employed in the growing of viruses and in the preparation of vaccines can serve as excellent supplementary material to textbook assignments when the disease unit is studied.

Questions

1. How does a vaccine make a person immune to a given disease?
2. What is a virus? How does it differ from a bacterium?
3. What are some diseases caused by viruses?
4. How does the method of growing flu virus compare with that used to grow polio virus?
5. Against which virus diseases are vaccines available?
6. What is a polyvalent vaccine?
7. What three lines of research on virus vaccines are going on at the present time?
8. What future developments in this field are foreseen?

Class discussion

Pass around the class a number of vials that once contained different kinds of vaccine. (These empty vaccine vials can be obtained from doctors, hospitals, and pharmacies.) Ask pupils to read the labels and observe that the vials are numbered and dated; also, that the strength of the vaccine is expressed in "units."

Discuss the significance of the information on the labels. Discuss how vaccines are transferred from the vial to the patient without coming into contact with the outer air.

No place like home

BIOLOGY TOPICS: animal behavior, ecology, geographic distribution, reproduction

GENERAL SCIENCE TOPIC: animal life

This article deals with interesting natural phenomena associated with localization of animal species. The phenomena discussed include migration, colonization, and territoriality, as manifested by a wide variety of animals, from limpets and army ants to penguins and deer.

When teaching the unit on ecology, the biology teacher will want to refer to the butterfly, *Oeneis.* The melting glaciers of North America left this butterfly stranded on the tops of the White Mountains of New England, the Rockies of Colorado, and the coast of Labrador.

The reproduction unit can be greatly enriched by reference to the strange wanderings of army ants, the incredible journeys of American and European eels, the uncanny way in which salmon return to their home-rivers to

spawn, and the transitory territorial behavior of the dragonfly.

The article is especially good as teaching material because it describes the work of such scientists as Griffin and Schneirla.

Questions

1. What limits the limpet to living on rocks in tide pools?
2. Why are penguins found only in the antarctic and on certain isolated islands in the Southern Hemisphere?
3. What are some of the discoveries that Schneirla made in his studies of the army ants of Barro Colorado Island in the Canal Zone?
4. For many years the origin of eels was a mystery, since no one saw them reproduce. How was it solved?
5. What method was used by Griffin in studying the migration of gannets?
6. How do scientists go about determining the homing area of the white-tailed deer?

Life of a western gladiator

BIOLOGY TOPICS: balance of life, behavior, reptile anatomy, ecology, reproduction

This life story of a rattlesnake is told from a snake's point of view. Nevertheless it is remarkably free from crass anthropomorphism. The story moves along with never a dull moment to a truly breath-taking climax. All along the way, from beginning to end, is a trail of authentic biological information. Flashes of vivid description reveal the relationships of this rattler to its physical and biotic environment. You learn how it is born, how it feeds, grows, molts, escapes its enemies, hibernates, and how it finally succumbs at the hand of the one enemy it cannot overcome — man.

What an exciting story with which to introduce a unit on ecology, behavior, reproduction — or even the biology course itself!

Questions

1. How does a newborn rattler compare with a full-grown rattler in length and thickness of body?
2. What are the distinctive markings of *C. atrox*?
3. What two western birds eat young rattlesnakes?
4. How do each of the following unique organs of the rattlesnake enable it to obtain its food: the pit between the eye and nostril, its tongue, its fangs?
5. What animals are the prey of young western rattlesnakes? Of *older* rattlers?
6. How does a rattlesnake get rid of its old skin when it molts?
7. How often does a rattler molt?
8. What are the effects of rattlesnake venom on an animal into which it is injected?
9. Where and how do western diamond rattlesnakes spend the winter?
10. At what age may a rattler reproduce? How many young does it have?
11. How long may a rattlesnake live?

Where weight disappears

PHYSICS TOPICS: Newton's laws (applications), mass, inertia, acceleration, gravity

GENERAL SCIENCE TOPIC: space travel

The physics teacher who is struggling to get his students to understand such concepts as weight, mass, and inertia will find Dr. Asimov's article very helpful. It explains these concepts in terms of some intriguing problems that man will someday meet aboard a space station.

Questions

1. Would the weight of an object change if it were taken from the top of a mountain to a valley below? From the North Pole to the equator?
2. Though the mass of the moon is 1/81 that of the earth, a man on the moon would weigh 1/6 of his weight on the earth. Why?
3. An artificial satellite in an orbit about the earth is revolving under the influence of the earth's gravitational pull. Why, then, would a man on that satellite experience a feeling of weightlessness?

Science teacher's question box

I find that my physics students often have trouble with simple math, even though they have had 2½ to 3 years of it. Is this the fault of the math teacher? — Physics Teacher, Chicago, Ill.

Probably not, since this is a common complaint. Though the math teacher is frequently blamed, the fact is that students tend to forget what they have learned. It's up to the physics teacher to review those math operations that are essential to his course.

How can I demonstrate the effect of chlorine upon micro-organisms in the purification of water? — P. S., New York, N. Y.

Place some water containing paramecia or other common protozoans in an open Petri dish on a microscope stage. Focus the microscope, and observe the organisms in motion. Then add one or two drops of laundry bleach. Laundry bleaches are usually a 5 per cent solution of sodium hypochlorite. Chlorine will be released in the water and will kill the organisms. When observed through the microscope, the field will show no movement, indicating the death of the protozoans.

Is there any real danger involved in allowing a chain of volunteer students to be shocked by a Model-T coil connected to a 6-volt dry cell? The purpose of course, is to demonstrate the conductivity of electricity through the human body. — L. P., San Francisco, Calif.

Though it's not probable that any students would be harmed, it's possible. The same demonstration can be safely performed by connecting your "chain" to an ohmmeter in the 50,000-ohm range.

What are some simple ways to demonstrate diffusion? — B. H., Watertown, Mass.

One of the simplest is to open an ammonia bottle (or, if you prefer, a bottle of strong perfume) in one corner of a room. Before long the odor caused by the diffusion of the gas or vapor will be noticed at the opposite end of the room.

To show diffusion through paper, place some ammonia water in the bottom of a small wide-mouthed bottle. Cover the bottle with wet filter paper. Inside a similar bottle, place a piece of moistened red litmus paper, and hold it in place with cellulose tape. Put this bottle in an inverted position over the mouth of the first bottle. As the ammonia diffuses up through the paper into the top bottle, the red litmus will turn blue, since the ammonia gas combines with the water in the litmus paper to form the base, ammonium hydroxide.

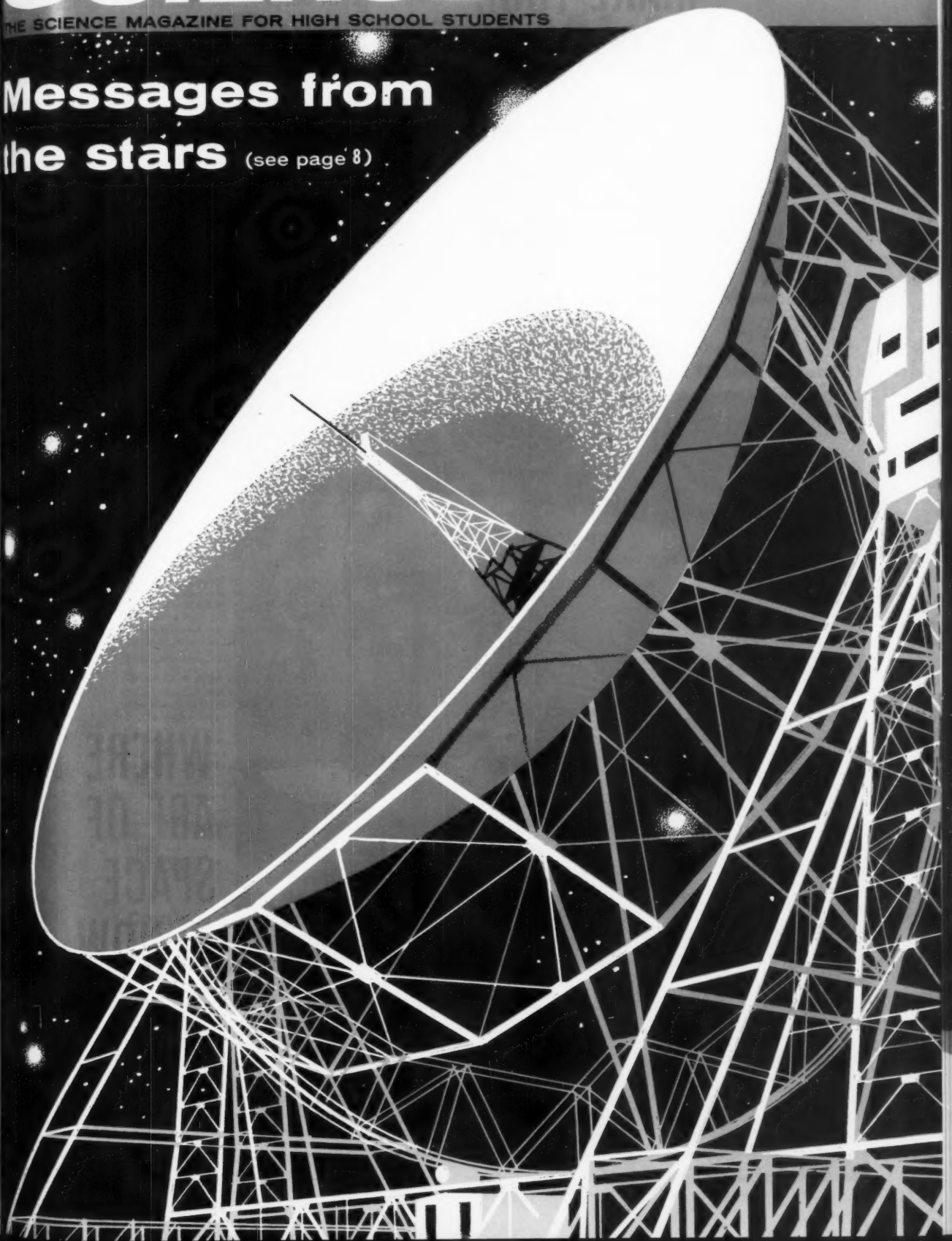
Questions from teachers will be answered here, as space permits. Send questions to: Science Teacher's Question Box, Science Teacher's World, 575 Madison Avenue, New York 22, N.Y. We regret that questions cannot be answered by mail.

FEBRUARY 24, 1959

SCIENCE WORLD

THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS

Messages from the stars (see page 8)



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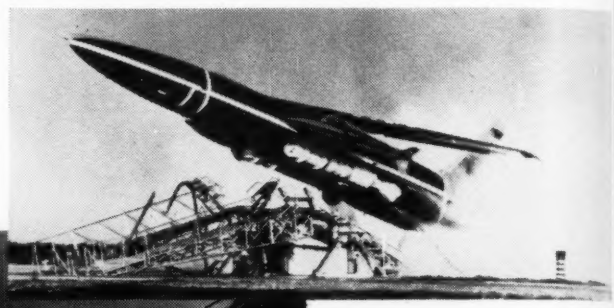

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Coming in SW, March 10

How does the world look through the eyes of a fly? How do insects rate as hunters and trappers?

In the modern world, noise is becoming an increasingly big problem. How are scientists tackling the problem?

How can the weather make you irritable or energetic, cause "spring fever"?

Today we can fuel rockets so that they will reach the moon. But how are we going to "fuel" human travelers to the moon?

For answers, see next issue of *SW*.

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Contents • February 24, 1959 • Vol. 5 • No. 2

Features

4 **No Place Like Home,** by John Paul Scott

8 **Messages from the Invisible Universe,** by Arthur C. Clarke

12 **Vaccines to Fight Viruses**

15 **Where Weight 'Disappears,'** by Isaac Asimov

Science Fiction

27 **The Life and Death of a Western Gladiator,** by Charles G. Finney

Departments

18 **Science in the News**

20 **Young Scientists: Logical Circuitry and Symbolic Logic,** by Theodore Benjamin

22 **Question Box**

23 **Careers: Corrosion Fighters**

26 **On the Light Side,** by George Groth

30 **Yours for the Asking**

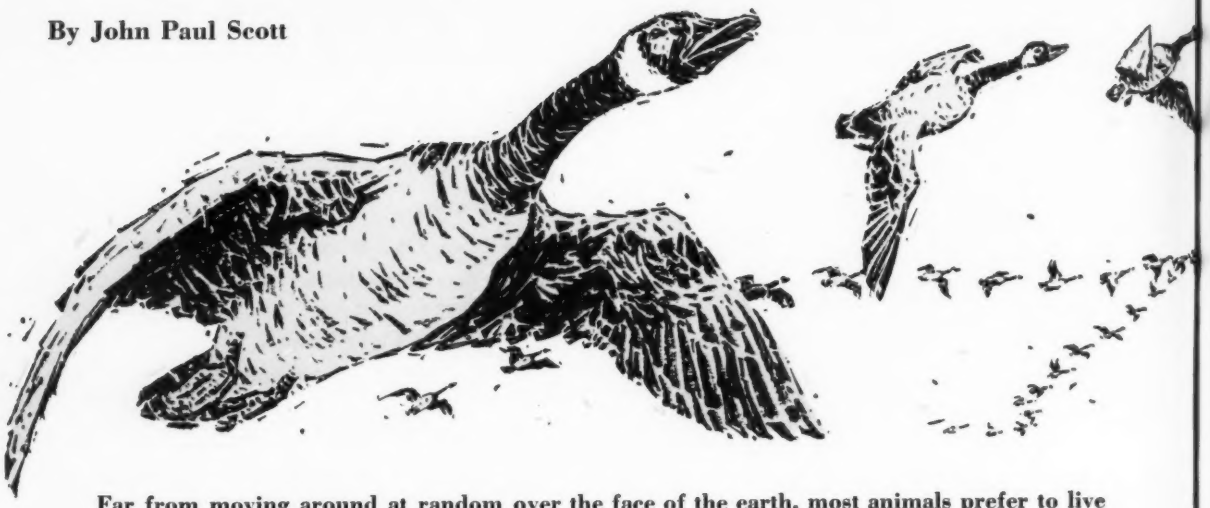
Cover by John Ballantine

From the editor's desk

"Question Box" is turning out to be the most popular feature we've ever run in *SW*. Reader questions pour in at the rate of a hundred or so a week — and they are, almost without exception, good questions. We try to choose for each issue a wide variety of questions in order to interest as many readers as possible. But it's a hard job to choose only five or six from the many questions that have come in. (It's no snap answering some of the questions either, we might add.) We hope, in time, to be able to answer all of them. Meanwhile, we'd like to say thanks to all of you who have sent them in. And we hope you'll keep them coming.

"Yours for the Asking" also has the mailman's bag sagging. And here we'd like to add a word of explanation about how these requests are handled. As you know, the materials listed are *not* published by *SW*, but are offered by various companies. Your requests are sorted here and forwarded to the companies involved. This process usually takes several weeks. So, if materials don't arrive as soon as you'd like them, please be patient. They will be along.

By John Paul Scott



Far from moving around at random over the face of the earth, most animals prefer to live where they were born and brought up. So, you might say, even among animals there's

No place like home

■ Any visitor to the seashore has seen limpets clinging tightly to the rocks in tide pools. If you can pry one loose, you find that underneath the shell these small mollusks resemble their relatives the snails, having a broad foot with a head and tentacles at one end. In the ordinary course of its life, a limpet crawls slowly around on a rock covered by high tide, grazing on the small marine plants which grow there. At low tide it clamps itself tightly to the rock, using the broad foot as a kind of suction cup. The success of this maneuver depends upon a right fit between the shell and the rock. When the English animal behaviorist E. S. Russell marked limpets for individual recognition, he found that they always returned to the same place at low tide and that, as the shell grew, it took on the shape of the particular piece of rock which was the home of the limpet.

John Paul Scott is chairman of the Division of Behavior Studies at the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine. A former Rhodes scholar, he received his Ph.D. in zoology from the University of Chicago.

This sort of behavior is very common among animals. The great majority seem to have definite preferred localities around which they spend most of their lives. These spots are usually the places in which they were born and grew up. This behavior suggests there may be a widespread phenomenon of becoming attached to a particular spot on the earth's surface. This behavioral process may be called *localization*, used in the sense that an animal becomes related to a particular place, rather than in the psychological sense of orientation with regard to sound. With localization, we begin to deal with behavior on the ecological level of organization.

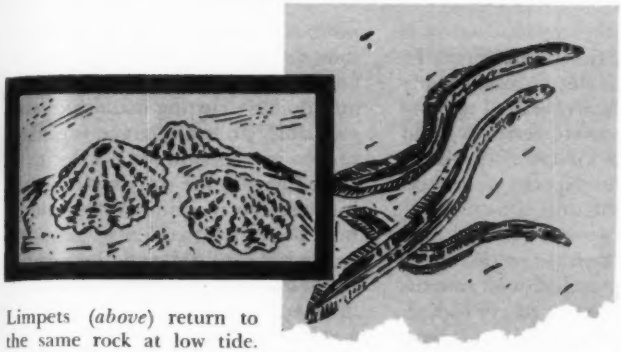
Primary localization. All of the evidence that we now have indicates that an attachment to a particular geographical spot is first formed early in life. Over 60 per cent of a group of house wrens banded as nestlings were later trapped within a mile of their original nest. White-tailed deer, which are now becoming so common in the American countryside, can also be caught and tagged as young animals and their subsequent movements followed. Even such large animals as these tend to stay most of the time within a half-mile radius of the place in which they grew up. The deer will not move even when food becomes scarce; and if they are forcibly driven to other places they soon come drifting back.

Even more spectacular examples are seen in some of the lower animals. Salmon, which live in the sea during adult life and return to fresh water to spawn, almost invariably come back to the same river in which they grew up. In one experiment, 11,000 tagged salmon were recovered in the parent stream, and none elsewhere. They are able to detect differences in the chemical composition of the water of different rivers and seldom if ever make mistakes. Learning to recognize the special type of river water must take place in early life before the seaward migration.

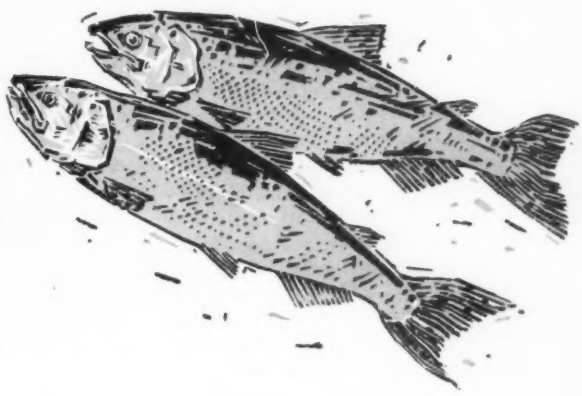
Orientation and migration. The fact that an animal's behavior becomes localized to a particular spot implies that it must be able to find its way back if it goes away. How this is done is well known in some species but remains an almost com-

Abridged from the chapter "Behavior and Environment" in the book Animal Behavior

Illustrated by William Bryant



Limpets (*above*) return to the same rock at low tide. Geese (*left*) migrate between two seasonal homes.



Eels (*above*) breed in the ocean, travel thousands of miles to their river homes. Salmon (*right*) live in sea. return to rivers to spawn.

plete mystery in others. The problem is particularly difficult in the case of birds, some of which fly over extremely long distances during migration. Various experiments have shown that birds are expert at finding their way back to their homes, and this ability has been used in a practical way for centuries in the case of the homing pigeon. Properly trained pigeons will find their way back from many miles away, but we still do not have the final answer to the problem of how they do it.

All the evidence indicates that birds have an excellent sense of sight and that they frequently fly at considerable heights. At comparable altitudes human beings can see a hundred miles in any direction in clear weather, so that it should be possible for birds to recognize landmarks from long distances. The best way to check these ideas is to study bird behavior directly, and the large, clearly visible sea birds can be followed in a slow-flying light airplane. Using this technique, D. R. Griffin found that gannets which had been taken four or five hundred miles away from their homes did not take direct paths back but did considerable circling around after being released, indicating that they might have been using visual landmarks.

It is also possible that birds make use of what we often call a "sense of direction." In people, this is based partly on visual landmarks but also on a sort of kinetic memory of the turns that have been made. A person with a good sense of direction rarely gets confused, even at night and when very gradual turns are made, as in the case of a railway journey. This ability is probably dependent upon the semicircular canals of the internal ear, and it is possible that birds have it developed to a much greater degree than people.

Even on these bases it is difficult to explain the feats of such migratory birds as the golden plover, which flies across the Pacific Ocean from Alaska to Hawaii with no landmarks en route. The suggestion has been made that such birds are charting their course by the sun or stars in the same way as human navigators. To do this with a ship, it is necessary to have an accurate clock and a sextant to obtain the angle of the sun, since its position changes with the time of day. It would not be too difficult for a bird to observe the angle of the sun with its eye while it kept its head level in flight, and, as for clocks to keep track of the passage of time, it is possible that birds have some sort of internal timing mechanism or "sense of time" which serves the same purpose. We know that rodents which run daily activity cycles use their exercise wheels at almost exactly the same time every day, even when kept in complete darkness with no clue to the time. Birds may be capable of doing the same thing. Whether this is the correct explanation or not, there can be no doubt that birds are remarkably good at locating themselves in space. It is perfectly possible that different species of birds use different methods or combinations of methods for orienting themselves, and that no one single explanation will fit them all.

The vast majority of perching birds migrate from their breeding grounds, which are usually in a cold climate, to winter feeding grounds in warmer areas. The movements of salmon, which migrate from rivers to ocean and back again in the course of their lives, have already been mentioned. Even more extraordinary is the migration of eels. These were a favorite food fish caught in the rivers of Europe, and when the colonists came to America they found a very similar species in the North American rivers. No one had ever seen their breeding grounds. Meanwhile, zoologists were busy collecting and classifying the fauna of the world and, among other things, discovered a curious transparent fish in the Sargasso Sea. They named this new genus *Leptocephalus*. It was eventually discovered that these small fishes were really immature eels, and the whole remarkable story began to come out. Breeding in the Sargasso Sea, the young eels gradually grow up and follow the Gulf Stream up through the North Atlantic. One species stops off in the rivers of North America and grows to maturity, while the other goes on across the ocean to Europe. The whole process takes several years, and the fish travel thousands of miles. It is possible that the

by John Paul Scott, by permission of The University of Chicago Press. Copyright 1958 by The University of Chicago.

young eels are simply carried along by the current and are attracted to fresh water at the proper time. The adult eels have to find their way back over a similar distance, and how they guide themselves is still a mystery.

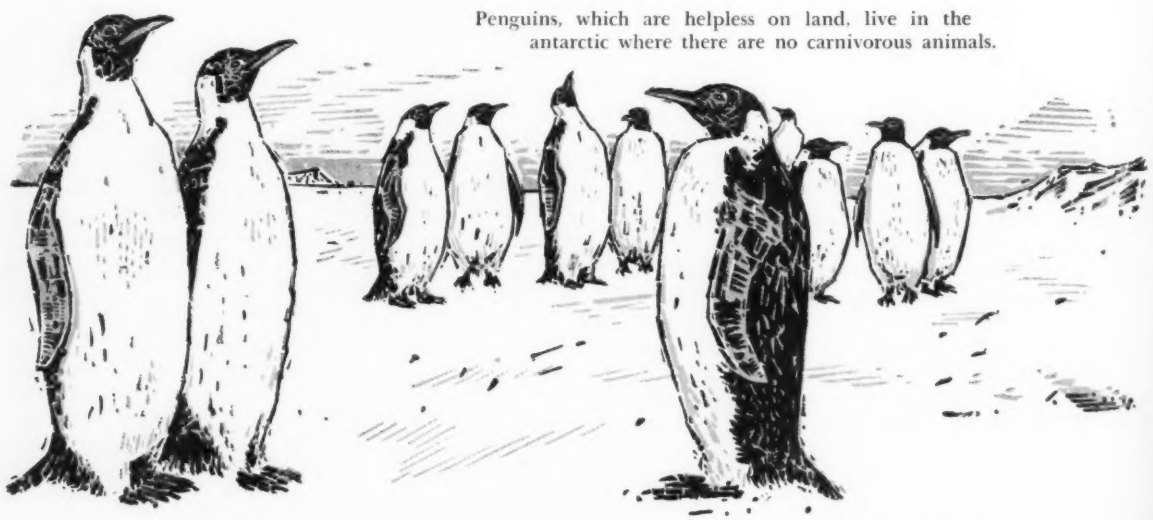
Colonization. As well as migrating between two locations, animals sometimes leave an old locality and find a new one. On an occasional warm day in autumn the air seems to be filled with flying insects, wings glinting in the sunlight and bodies splattering against the windshields of automobiles. When we examine the bodies, they often turn out to be winged ants. The usual ant colony has no winged members, but at intervals broods of winged males and females are produced, which then swarm forth all together. The males and females mate, and after a nuptial flight each pair settles down and attempts to form a new colony. A great many ants are killed or lost, but the behavior has the effect of spreading the species over the countryside and establishing new colonies wherever this is possible.

All animals have this problem of dispersal or distribution, and in some species there is a regular period in the life cycle which is devoted to the process. However, in many of the highly social vertebrate animals the processes of socialization to a particular group and localization to a particular spot strongly interfere with dispersal. In some there does not seem to be any regular and effective way of moving rapidly into vacant territory, and this creates a practical problem when a valuable species is threatened with extinction.

Nomadic wandering: the army ants. The vast majority of animals seem to have regular places to live. Even when they undertake enormous migrations like those of eels, it is between fixed locations. One of the few exceptions to the rule are the army ants, which have been so thoroughly studied by T. C. Schneirla in the jungles of Barro Colorado Island in the Canal Zone. These creatures live only in tropical regions, and their unusual way of living has given rise to many legends about their ferocity and irresistible power. Although many of these tales are false, the facts are interesting enough without exaggeration. In the first place, the ants do not destroy the vegetation as they advance, since army ants are entirely carnivorous. They eat chiefly insects and worms and, contrary to imaginative reports, never trouble any vertebrate which is big enough to get out of their way. They do destroy many fledgling birds, and a large animal which was completely crippled might be killed by multiple stings. The South American army ants would not be able to eat it, however, since they do not have the right kind of mouth parts. The African driver ants do have cutting mandibles and are able to eat larger animals caught in some kind of accident.

Ordinarily, the ants have a central location in which a large number of individuals are grouped around the queen and the young. From this area the workers start out in one direction. At first there is a principal trail with a heavy traffic of ants upon it. As it gets farther away from the central bivouac, it spreads out like the branches of a tree. It is from the tips of these branches that the ants spread out to catch their prey. Ants may be going in both directions on the principal trails, and a veritable traffic jam sometimes results. Communication is maintained chiefly by scent trails and direct bodily contact. The raids usually start early in the morning, with activity lessening around noon. At the end of the day the ants return to the bivouac for the night.

Every so often the ants go into a migratory phase. Instead of coming back to the original site, all the ants, including those forming the bivouac, move out along the trail each night to a spot one hundred yards or so away. The new bivouac or nest is made again from the bodies of living ants, which usually find a protected spot under a log and begin to form a nest by hang-



Penguins, which are helpless on land, live in the antarctic where there are no carnivorous animals.

ing down from it in strings by small hooks on their legs. In this way a solid wall of ants is formed around the queen and young.

The wanderings of the ants are correlated with the reproductive cycle. As long as the young are in the pupal stage the ants stay in one spot, and when the new brood emerges they become more active and move from place to place. Weather conditions have some effect on the amount of movement and the location of the nest, but ants move on at the right time, whether or not the food supply in the locality has been exhausted. There is no indication that any one colony stays in a particular locality, and the army ants are thus a very unusual kind of animal society, one that is truly nomadic.

Limitations of movement. In addition to the behavioral processes that result in positive attraction to particular spots, there are other factors which limit the free movement of animals. Even army ants never move far in the course of a season because of the difficulty of moving while the young are being raised. Other species like clams and mussels move extremely slowly or not at all. Besides these internal limitations, there are all sorts of external barriers which tend to keep animals in one place.

Social barriers: territoriality. Most perching birds set up territories during the breeding season and attack any strange bird which crosses over the line. This effectively prevents free movement of the parent birds and keeps them close at home. Somewhat different arrangements are found in other animals. Most of the small rodents which have been studied live in definite locations or home ranges. They do not guard geographical boundaries, but, if they come into contact with other animals, fighting results, and they soon learn to avoid each other and stay fairly close to one spot.

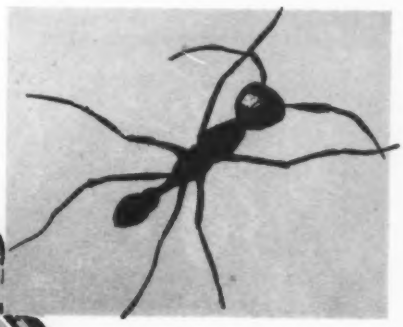
We still do not know how widely territoriality may occur in the animal kingdom, since new cases are constantly coming to light. Many male fish, like the sticklebacks and sunfishes, defend the territory around their nests, and male lizards seem to defend particular areas.

Even some species of insects show territoriality. During the breeding season male dragonflies patrol an area about fifteen feet long and three feet wide along the edge of a pond and drive out any other males. As might be expected in such short-lived animals, this behavior lasts only about ten days for each individual, which is soon replaced by another.

Ecological barriers. In a great many cases the movement of animals is restricted by the kind of environment in which they can live successfully. The limpet cannot get too high out of the water or it is exposed to dryness and the attacks of land-living predators. Nor can it get too deep in the water or it will run out of the plant food on which it exists. Many land animals are kept in one place by physical barriers such as water or unfavorable areas like deserts. One interesting example is the butterfly *Oeneis*, which is found only on the tops of the White Mountains of New England, the Rockies of Colorado, and the coast of Labrador. For this butterfly a warm climate seems to be an effective barrier, and those in the different regions have been isolated ever since the last glacial period.

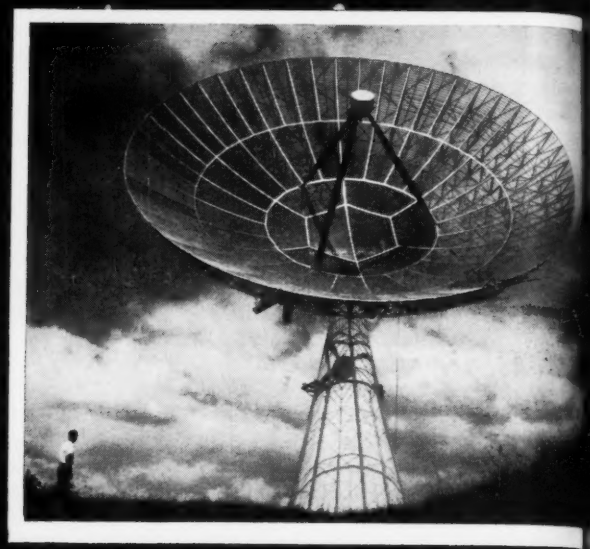
Biological barriers may be just as effective as physical ones. Penguins are expert swimmers and divers and can travel long distances over the ocean, but are slow-moving and helpless on land. They live only in Antarctica and certain isolated islands in the Southern Hemisphere, presumably because there are no carnivorous mammals like polar bears and foxes in these regions.

There are thus both positive and negative factors which tend to keep animals in particular places. In fact, with so many external and internal factors controlling movement, the problem of colonizing a new area is a difficult one for many species.

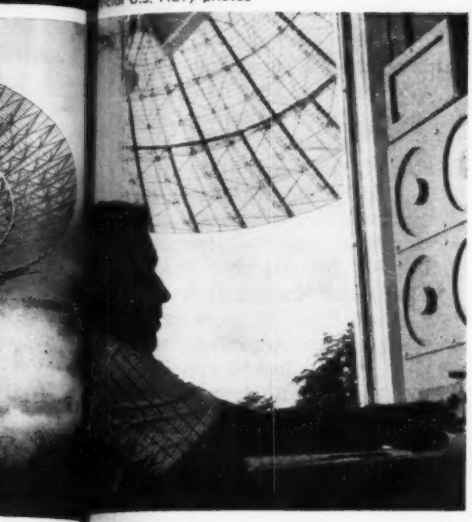


With no landmarks to follow, the golden plover (*left*) flies from Alaska to Hawaii. The army ant (*below*) is one of the few animals that doesn't have a regular home.

Messages from the invisible universe



Official U.S. Navy photos



TECHNICIAN AT CONSOLE steers Navy's 84-foot radio-telescope (country's largest) at Maryland Point, Md. (*left*). The Crab nebula (*at left*) is debris of exploding star, a powerful radio source.

By Arthur C. Clarke

■ For thousands of years men have looked up at the sun, moon, and stars — and believed that they saw the universe. Within the last decade, we have discovered that they saw — even with the greatest telescopes — only *one* universe, and that another exists, invisible to the eye. This is the universe revealed not by light, but by the millionfold longer waves of radio. It has been a revelation indeed; today's astronomers are like blind men who have suddenly been granted the gift of sight. It will be years before they can fully interpret what they observe — or rather what their wonderful new instrument, the radio-telescope, observes for them.

The discovery of radio waves themselves is still less than a century old; it was as recently as 1873 that the great physicist James Clerk Maxwell predicted their existence theoretically, and not until 1888 that Hertz first generated them in the laboratory. The swift rise of radio communication in the 1900's is one of the romances of modern technology, but for a long time it never occurred to scientists that nature, as well as man, could produce radio waves. It was true that brief bursts of "static," or electronic interference, accompanied lightning flashes — as everyone knows who has ever listened to a radio program during a thunderstorm — but this was not considered to be of very great scientific importance, though it gave the meteorologists a useful tool for tracking distant storms.

The first man to suspect that we might be missing something was a Bell Telephone Laboratories engineer named Karl Jansky, who was trying to hunt down the source of the background noise which can be heard in any radio receiver when the volume is turned full up and no station is tuned in. Some of this familiar hissing or frying sound originates in the set itself, but part of it is picked up by the antenna. In 1931, Jansky made the surprising discovery that part of this radio noise came from outer space, from the general direction of the Milky Way. This discovery would have earned Jansky a Nobel Prize if anyone had appreciated its significance at the time; but it could not be fitted into the general pattern of accepted science. So, for almost fifteen years, it was virtually forgotten.

It took the radar developments of World War II to bring the facts of radio-astronomy so forcibly to the attention of scientists that they could no longer be overlooked. Early in 1942, the British Army's anti-aircraft radar was suddenly and inexplicably jammed by a new type of interference. Naturally, the Germans got the blame, but it did not take long to discover that the trouble was a good deal farther away. The "jamming" was coming from the sun.

At the time, this was a well-kept secret, but immediately after the war the scientists concerned — mostly British and Australian — started following up this new line of investigation with great energy. They were much helped by the fact that large quantities of surplus radar equipment could be picked up for a song, and most of the first radio-astronomy equipment was built around converted radar sets.

A modern radio-telescope is, basically, a device for picking up and amplifying radio waves from selected small regions of the sky. Various types of directional antenna systems are used; some resemble TV arrays, but the best-known (and certainly most spectacular) are the huge parabolic bowls of which the 250-foot-diameter instrument at Jodrell Bank, Manchester, England, is the largest example. This great mirror, which has tracked all the sputniks and American satellites, concentrates radio waves in precisely the same way as the more familiar type of optical reflector — such as the 200-inch instrument on Mount Palomar in California — concentrates light waves. However, because of the much greater length of the waves, even a 250-foot radio-telescope has a somewhat fuzzy view of the universe. Objects which are closer together than a quarter of the moon's diameter cannot be clearly separated, but appear to overlap. Even a small optical telescope can do a thousand times better than this when it comes to resolving minute detail.

And unlike an optical telescope, which can produce dramatic and exciting photographs, the output of a radio-telescope consists of nothing but wavering lines on chart paper. The energy picked up by the bowl and concentrated at its focus is amplified by a very specialized apparatus which measures and records the strength of the incoming waves. (Sometimes the readings are tabulated automatically by electric typewriters, so that the telescope simply turns out columns of figures as it scans the sky!) Only experts, therefore, can interpret the results and say whether a sudden surge of power — recorded as a jump in the graph or an increase in the tabulated numbers — is due to local man-made interference or to some natural source, perhaps millions of light-years away.

These natural sources fall into several very different catagories, and there are certainly many others still to be discovered. One of them, as the British Army's radar experts found to their discomfort, is the sun. However, the greater part of the time the sun is not a very powerful source of radio waves; if you

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listen to it on a sensitive receiver you will usually hear only a gentle sizzling. But occasionally, when the enormous dark blemishes known as sunspots cross the solar disk, the output of radio waves increases by many millionfold. Another potent source of radio emissions is flares — sudden eruptions of incandescent gas from the sun's surface, on a scale that makes our most violent H-bomb explosion about as impressive as the popping of a paper bag.

Precisely how these torrents and whirlpools of flaming gas, at temperatures of thousands of degrees, and moving at hundreds of miles a second, act as generators of radio waves is still being investigated by scientists. Their work will lead to a much better understanding of the sun, and it is also linked with research which before long may transform life here on earth. For the study of such electrified gases is an essential step on the road to thermonuclear power — the release of the sea's infinite energy, to be extracted in the form of deuterium, for the use of all mankind. The sun started fusing hydrogen several billion years ago; now we are learning from its example.

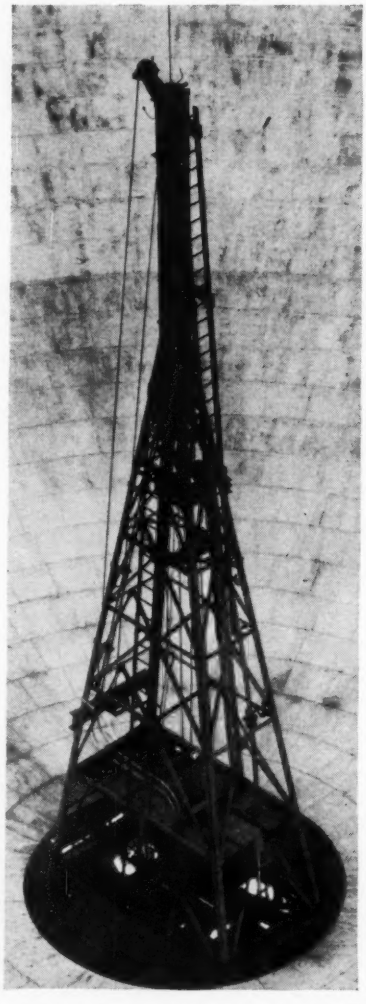
That the sun was a source of radio waves did not surprise the astronomers greatly, though they were rather taken aback by the strength of its most violent transmissions. What no one could have foreseen, however, was that radio waves would also be received from far colder bodies such as the planets Venus and Jupiter.

In the case of Venus, the earth's perpetually cloud-covered twin, the intermittent radio disturbances may come from something analogous to thunderstorms. Being nearer the sun, Venus is a good deal hotter than the earth, and its weather must be — to put it mildly — tropical. In any event, the bursts of radio noise emerging from beneath the eternal clouds may give us our first definite information concerning conditions on the hidden surface of the planet.

The case of Jupiter is much more mysterious. This giant planet, its diameter ten to eleven times that of the earth, is a hundred degrees colder than the most frigid Antarctic night — so cold, indeed, that most ordinary gases are liquefied. Yet somewhere deep down in the turbulent, half-frozen slush of methane, ammonia, and hydrogen, through which move floating islands bigger than our planet, are radio sources of immense power, generating millions of times more energy than terrestrial thunderstorms.

Very feeble radio waves have also been detected from the moon and Mars. These, however, are merely the waves that are produced by any object not at the absolute zero of temperature, simply through heat vibrations of its molecules. The radio waves that come from Jupiter and the sun are vastly more powerful than can be explained by this "thermal" effect and must have a completely different origin.

— Photo from B.I.S.



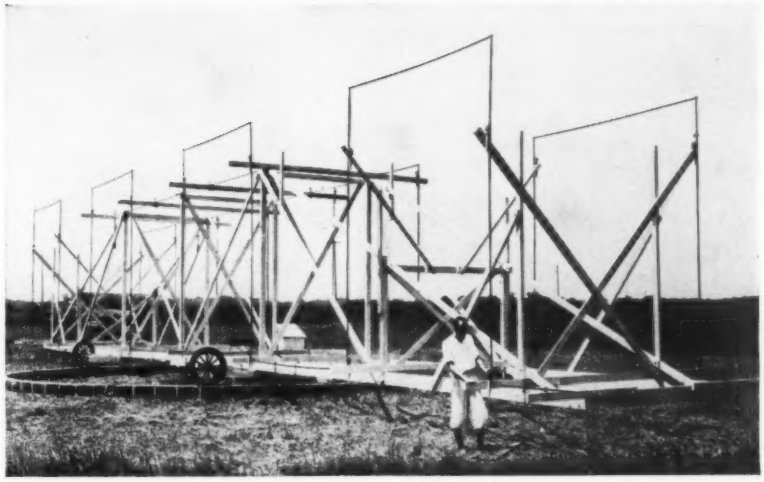
THIS IS AERIAL of Jodrell Bank radio-telescope (see cover, also). Bowl gathers and concentrates radio waves, focuses them at receiving aerial.

But the greatest of all radio transmitters in the universe are far more remote than sun and planets, and their investigation leads us back to Jansky's original discovery. If our eyes could respond to radio waves as they do to light waves, most of the sky would appear covered with a faintly glowing mist. The glow would concentrate into a bright band closely matching the position of the Milky Way, but scattered over the heavens would also be hundreds of individual points of radio "light," some of them extremely brilliant. These were originally, and rather naturally, given the name "radio stars," but it was soon found that most of them did not coincide with any outstanding visible stars. The astronomers were suddenly confronted with an entirely new picture of the sky, and the attempt to find the origin of the radio emanations (or discrete sources, as they are now more non-committally called) has been one of the most fascinating scientific detective stories of the past decade.

Some of these radio sources — millions of millions of millions of times more powerful than any transmitters built by man — are filaments of heated gas, expanding and twisting through space with great velocity. They may be the debris of exploding stars; indeed, this is known to be the case for one of the most powerful radio sources: the Crab nebula — remnant of a cosmic catastrophe which the Chinese astronomers observed as a brilliant but short-lived new star in A.D. 1054.

These swirling gas clouds, calling attention to their existence by the roar of their radio voices, are merely local eddies in that whirlpool of stars, the galaxy. Though they are far larger than the solar system, being many light-years across, they are still very small on the cosmic scale. And as radio transmitters, they cannot be com-

— Photo from Bell Telephone Laboratories, Inc.



THE LATE KARL G. JANSKY of Bell Telephone Laboratories with the rotating antenna that he used in his discovery that radio waves were coming from the Milky Way. At the time (1931), the discovery went unappreciated, for it could not be fitted into the general pattern of science. So for 15 years it was almost ignored.

pared with the most stupendous source of radio energy yet discovered.

This lies in the direction of the constellation Cygnus, but it is a million times farther away than the cross-shaped group of stars which outlines the figure of the flying swan. It is pouring out radio waves at the unimaginable rate of 1,000,000,000,000,000,000,000,000,000 (thirty zeros) megawatts; for comparison, a very high-powered radio transmitter may broadcast *one* megawatt. When this intense source was discovered barely ten years ago, the astronomers were baffled, because the best telescopes could find nothing visible to account for it. Eventually, photographs taken at Mount Palomar by Baade and Minkowski revealed a tiny smudge of light which has now been interpreted as one of the most awe-inspiring phenomena yet discovered. It is nothing less than the head-on collision of two galaxies.

This is indeed a phrase worth savoring with the mind, but the word "collision" is a little misleading. It will take millions of years for the two great systems of stars to sweep through each other, and it is most unlikely that even a single pair of stars will actually come into contact, so vast are the distances between them. It is the violent interaction between the tenuous gas clouds between the stars that generates this tremendous pulse of power. Even from 270,000,000 light-years away, it dominates the radio sky.

Conditions must be very peculiar in a region so drenched with radiation as the Cygnus radio source. Radio communication would be as impossible as a quiet conversation in a jet-engine test cell. It is difficult to see how the inhabitants of any planets in these colliding galaxies could ever discover the laws of electromagnetism in the presence of such a roaring background of power.

And this leads us naturally to a question which many people would like to ask, but which the astronomers are chary of answering. Is there any evidence at all of signals due to intelligence among the barrage of radio noise pouring down from space?

Not yet; nor could it reasonably be expected in the present early stage of this new science. The natural radio transmitters scattered round the sky are quadrillions of times more powerful than any that even the most advanced civilizations could possibly build; against the cosmic cacophony, the voice of intelligence could be only the faintest of whispers. Our own radio signals now fill an expanding sphere of space more than a hundred light-years across; Marconi's first transmissions have already traveled fifteen times farther away than the nearest star. But long before they leave the solar system, our most powerful broadcasts fade so far below the background of interstellar noise that they are as undetectable as words that were spoken yesterday.

No receiver, however sensitive, can pick up signals once they have sunk below the noise level. And if we ever do detect intelligent signals from space, the beings that produced them may no longer exist — such is the slowness of radio waves, compared with the immensity of the universe. That soundless thunderclap from the colliding galaxies in Cygnus started on its way before the great reptiles trampled the earth.

Yet, though they may deny it with some indignation, many radio-astronomers must cherish the secret hope that some day they will detect signals that do not have a natural origin. The telescopes already built — even the 250-foot Manchester giant — are the products of the very first decade of radio-astronomy. One day they will be superseded by far larger instruments, possibly miles across.

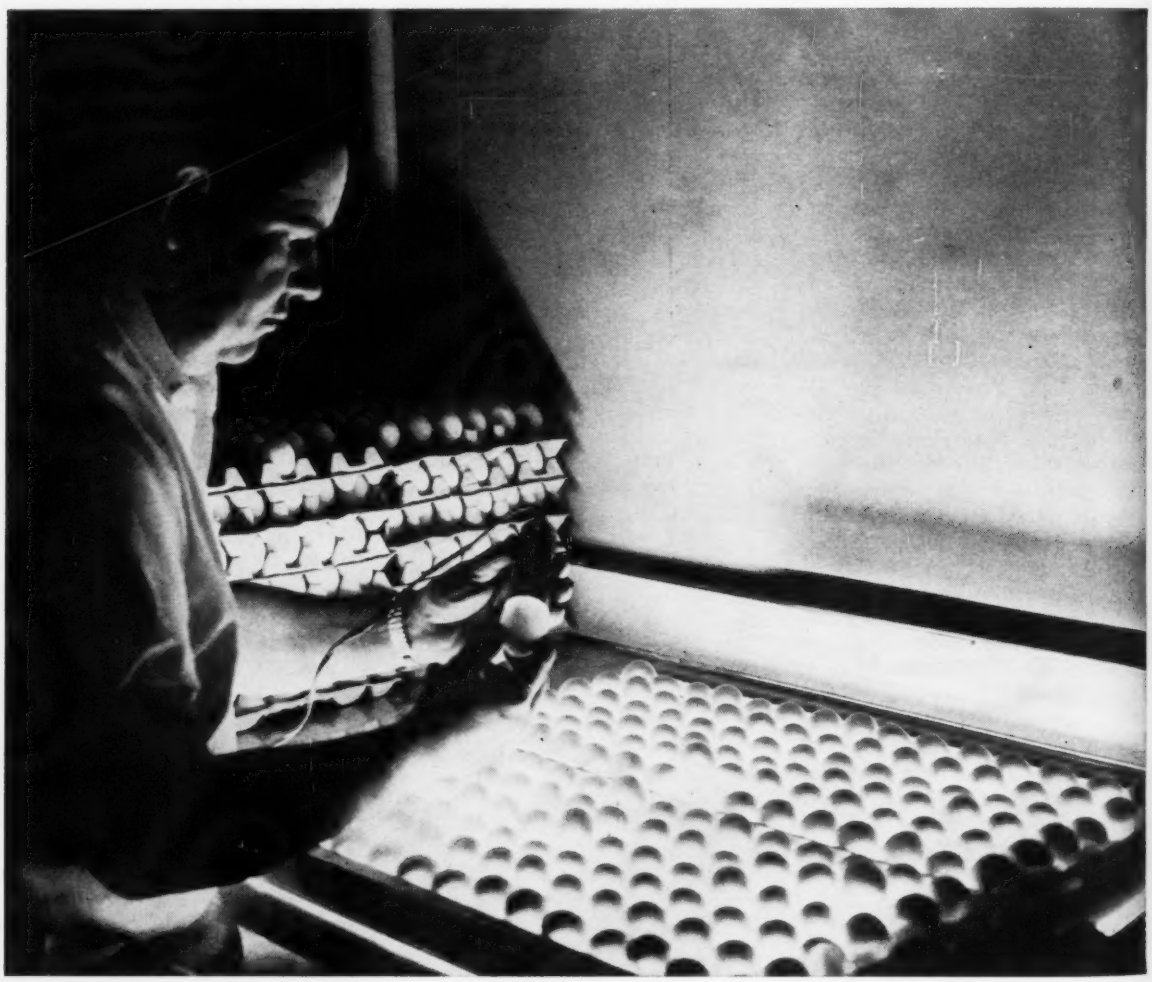
These will not be built on the earth's surface but will be assembled in satellite orbits, where the absence of gravity will permit the use of paper-thin materials and ultra-light construction techniques. Clear of the man-made interference which now drenches our planet, they will be able to gather far more energy than today's antenna systems and, what is equally important, will be able to focus with much greater precision upon selected small regions of space. We can be certain that these vast instruments will bring us much nearer to a true understanding of our universe; and we can hope that, one day, they will tell us that we are not alone in its immensity.

Vaccines to fight viruses

■ In 1796, an English country doctor named Edward Jenner vaccinated a young boy against smallpox. The boy became immune to the disease. Though Jenner had no idea why his injection worked, it made medical history. Since then, vaccines have been developed to combat a long list of diseases, including typhoid fever, yellow fever, influenza, and polio.

A vaccine usually consists of the killed or weakened organisms that cause a particular disease. When the vaccine is introduced into the blood stream, it triggers the body's natural defenses. Special substances called antibodies are formed. These destroy the disease organisms or neutralize the effects of their poisons. The antibodies remain in the body and make the person immune to the disease.

[*Continued on p.* 14]



CANDLING OF EGGS is first step in production of flu vaccine. Light makes shell translucent so that chick embryo inside egg can be seen. Eggs that are fertile are placed in an incubator for eleven days. Non-fertile eggs are discarded.

LIVE FLU VIRUS is injected through holes drilled in fertile eggs that have been incubated. When re-sealed and incubated again, eggs will provide ideal hosts for the virus and containers in which it can multiply.

ROUND HEATING IRON removes tops of virus-containing eggs after 48-hour incubation.

ON 'HARVESTING LINE,' virus-rich fluid is drawn from eggs by suction tube into large bottles. The fluid is then spun in centrifuge machines (*right*) to separate virus from egg fluid. Virus is now ready to be used in vaccine preparation.

Vaccines are particularly important as weapons against virus diseases — polio, influenza, and others. The reason: unlike bacteria, many viruses cannot be readily stopped by antibiotics and other drugs. So vaccines are the chief defense against them, preventing — rather than curing — virus diseases.

Viruses occupy the shadow world between living and non-living things. Scientists aren't sure to which group they belong. So small they cannot be seen under an ordinary microscope, viruses will grow only in living cells. This means that growing viruses in quantity for use in a vaccine presents a problem — or, at least, it used to. Viruses are now grown in tissue cultures (bits of animal tissue growing in a nutrient bath) and in chick embryos. The rapidly propagating cells of the chick inside the egg provide an especially convenient "living laboratory" that contains everything the viruses need to flourish. The accompanying pictures show steps in the making of vaccines produced by the pharmaceutical firm of Chas. Pfizer & Co., Inc.

Though great strides have been made in vaccine research, it is still one of the exciting frontiers in medicine. One day, scientists hope to develop vaccines that will eliminate most virus diseases. These now cause 250 million cases of illness in America each year.

"One of the newest trends is toward polyvalent vaccines," says Dr. Joel Warren, head of research at Pfizer's biologics research department. "Scientists are now at work on the methods of combining various biologics into a single shot."

Already, there is a three-pronged shot that gives protection against whooping cough, diphtheria, and tetanus. And new vaccines used by the armed forces give protection against as many as six types of influenza. Eventually, some researchers predict, we'll be able to get immunization against two dozen diseases with only one shot.

Dr. Warren points to three other promising areas of vaccine research:

1. Study of the possible tie-up between cancer and viruses. If this tie-up can be proved and the viruses isolated, vaccines to fight them will be the next step.

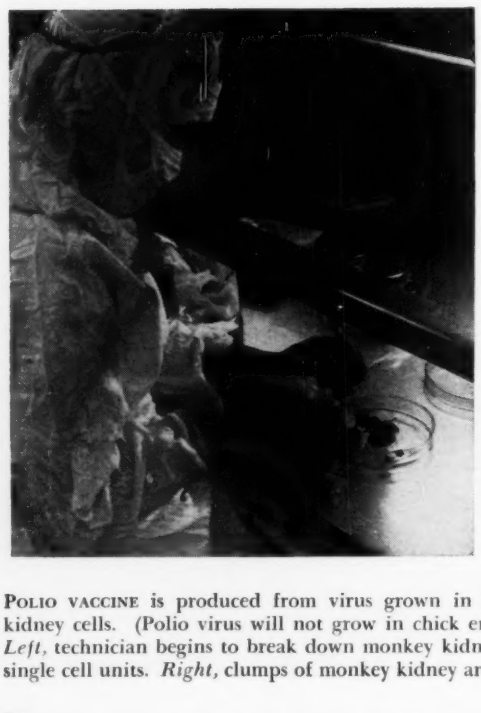
2. Development of new vaccines to control the common cold and other respiratory infections.

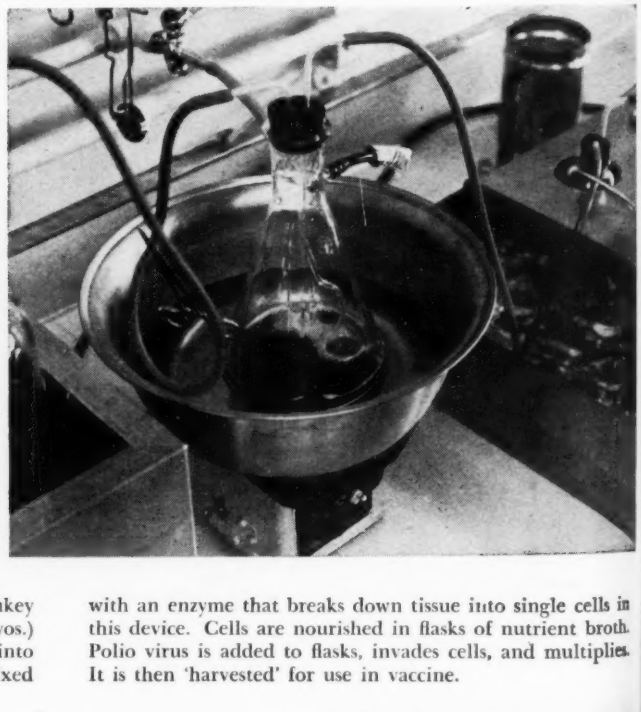
3. Development of a vaccine against measles.

And what of the future? What problems may be tackled in this amazingly fast-changing field?

"Development of oral vaccines using live viruses is a very likely prospect," says Dr. Warren. He also foresees striking developments in the use of tissue-culture techniques. In the near future, scientists may learn how to maintain living organs and tissues over long periods of time. In the far future, it may be possible to grow a whole organ from samples of the organ's tissue. What's more, tissue-culture techniques may have important applications even outside the field of medicine. Growing cells in tanks on simple media, says Dr. Warren, may one day supply food for the world's exploding population.

— Photos courtesy of Chas. Pfizer & Co., Inc.





POLIO VACCINE is produced from virus grown in monkey kidney cells. (Polio virus will not grow in chick embryos.) *Left,* technician begins to break down monkey kidneys into single cell units. *Right,* clumps of monkey kidney are mixed with an enzyme that breaks down tissue into single cells in this device. Cells are nourished in flasks of nutrient broth. Polio virus is added to flasks, invades cells, and multiplies. It is then 'harvested' for use in vaccine.

By Isaac Asimov

Where weight 'disappears'

Before you volunteer for duty on a space station, you'd better learn the difference between mass and weight — and the answer to such questions as: Could you crack a nut with a 'weightless' hammer?

■ A paper given at the recent meeting of the American Association for the Advancement of Science talks about the possibility of building a station in space. We've all seen drawings of space-suited men easily maneuvering the large girders that will go into the construction of such a station. The girders can be handled easily, we are told, because out in space there will be no feeling of weight.

But why not? After all, weight is a measure of gravitational pull. Doesn't the earth's gravity extend the thousand miles or so to where the station will be built? Surely it must, since it holds the moon, which is a quarter of a million miles away, in an earth-circling orbit. Then why will a space station be in a state of apparent weightlessness?

And if the girders are "weightless," will men really be able to toss them from hand to hand like feathers? Suppose a man is struck by a "weightless" girder. Will it hurt him? For that matter, will it be possible to use "weightless" tools? Could you hammer a nail into a board with a "weightless" hammer, or crack a nut with one?

We don't have to go out into space to find the answers. They are already known. In fact, they've been known for more than 200 years — since the time of Isaac Newton.

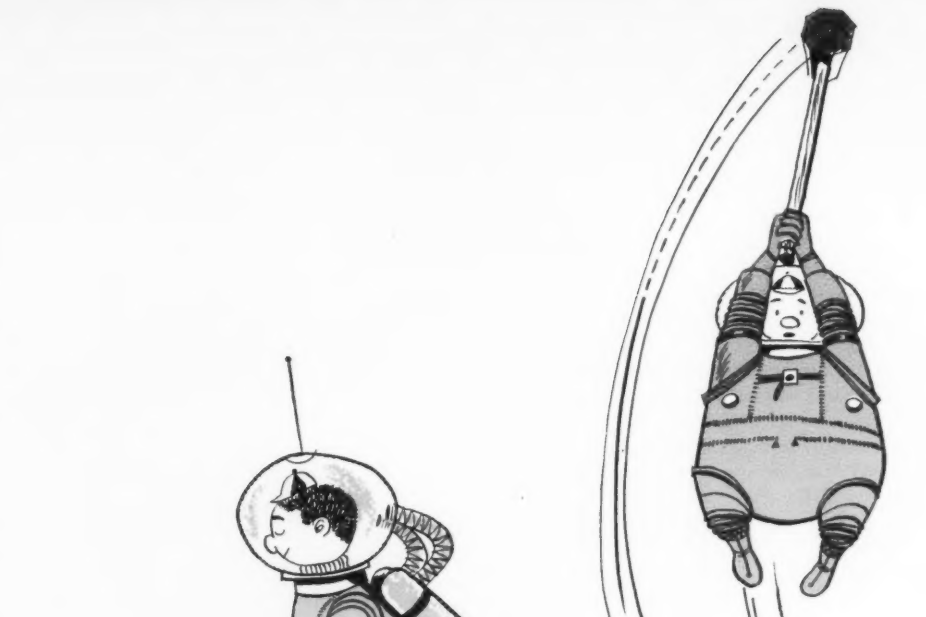
But to understand how the answers can be worked out, we must go back to some fundamentals. In the article, "The Fickle Measurement — Weight" (*SW*, Feb. 10), I explained that the weight of a body on the earth depends on two factors: its mass (the amount of matter it contains) and its distance from the earth's center. For that reason, an object weighs less upon a mountaintop than in a valley below. Also, it weighs less at the equator (where it is farther from the earth's center because of the "equatorial bulge") than at the poles.

There is a third factor involved in measuring an object's weight (which is, as I've said, only the measure of the gravitational pull upon the object). That third factor is the mass of the body doing the pulling. Since all our weighings are conducted on the earth's surface, we don't usually worry about that. It is always the earth that is doing the pulling, and the earth's mass is always the same.

But suppose we weighed an object on the surface of the moon. There, the moon would be doing the pulling. The moon has a mass of only 1/81 that of the earth, so its gravitational pull would also be only 1/81 that of the earth.

Does that mean that an object weighing 81 grams on the earth would weigh only 1 gram on the moon? Well, no. That would be so if the object being weighed were the same distance from the center of the body doing the pulling each time. But it wouldn't be.

On the surface of the earth, the object would be about 3,900 miles from the center of the earth. But on the moon, a smaller body, the object would be only 1,080 miles from the moon's center. At this closer distance, the moon's gravita-



tional pull would be nôt 1/81 that of the earth, but 1/6.

In other words, a person weighing 150 pounds on the earth's surface would weigh about twenty-five pounds on the moon's surface.

Before man lands on the moon, however, he will probably ride a satellite into an orbit around the earth. He will then experience an even more peculiar change — the apparent disappearance of weight.

Suppose the satellite was orbiting 1,000 miles above the surface of the earth. The passenger would then be 4,900 miles from the center of the earth. The earth's gravitational force would be weaker at that height — roughly 5/8 that of the earth's surface. Why, then, would the man feel weightless? Why wouldn't a 150-pound man weigh 5/8 of his normal weight, or about 94 pounds?

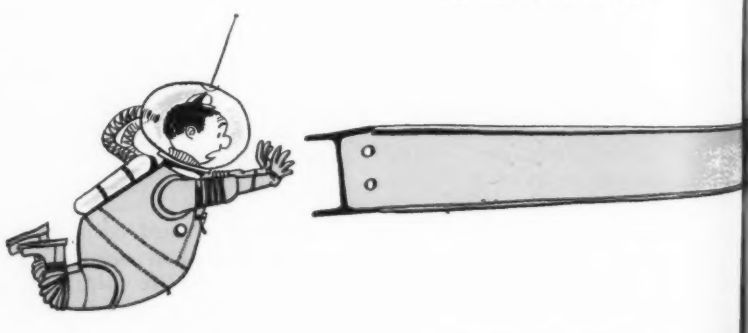
He would weigh 94 pounds only if he were motionless with respect to the earth — if, for example, he were standing on a mountaintop 1,000 miles high. But a man in a satellite would be in motion. That would make a difference.

The apparent weightlessness of a satellite can be explained as follows: The motion of the satellite tends to throw it outward in a tangent. When this outward-moving tendency balances the inward pull of gravity, there is a feeling of weightlessness.

This brings us to the question of how "weightless" tools could be used aboard a satellite or space station. The key point is this: though the tools have seemingly lost all weight, their mass remains unchanged. A one-kilogram hammer may seem to weigh nothing, but it still has the same amount of matter in it. And it is the mass of the hammer, not its weight, that drives a nail or cracks a walnut.

Why is this so? Because mass has something associated with it called *inertia*. This is a kind of resistance to change. Any object at rest stays at rest until some force sets it in motion. Any object already in motion moves in a straight line at a constant speed forever unless some

Illustrated by Paul Granger



force alters its direction or speed or both.

Any alteration in the rate or direction of an object's motion is called *acceleration*. What I am saying, then, is that it takes force to produce acceleration. The amount of force it takes to produce a given amount of acceleration is the measure of inertia, and it depends only upon the mass of a body and nothing else.

One common force in the universe is that of gravity. An object falling to the earth is being accelerated because it falls faster and faster with time: its rate of motion is changing. A satellite circling earth is being accelerated because its direction of motion is constantly changing.

Now imagine yourself on a space station bringing down a hammer upon a nut. The hammer is moving rapidly as it strikes the nut. So the nut must exert a force to halt the hammer. And the force is great enough to break the nut's shell. The fact that the hammer is "weightless" doesn't matter. The nut is cracked by the hammer's inertia.

But there would be a difference with a "weightless" hammer. On the earth, a hammer's weight helps you crack a nut. Gravitational force helps bring the falling hammer to the proper nut-cracking rate of motion. On a space station, you would have to do this work yourself.

Imagine a huge sledge hammer that, on the earth's surface, you can barely lift. If you manage to get it waist-high, you can let it drop on a rock and shatter the rock. It is gravitational force, entirely, that accelerates the sledge hammer to the necessary speed.

But on a space station, in the absence of gravity, you would have to force the sledge hammer downward to give it the necessary speed to shatter a rock. *You* would have to do the work that gravity would do on the earth's surface.

Once you managed to get the sledge hammer moving rapidly enough, however, it would be just as effective in shattering rocks as if it had its normal weight. As I've pointed out, the sledge hammer's large mass and, consequently, large inertia would see to that.

This, in fact, makes an important point. Though a sledge hammer on a space station might be lighter than a feather, it would not behave like a feather at all. If the sledge hammer were already at waist-height, you could hold it there with the tip of your little finger. You would not be trying to change its motion, so you would not be fighting inertia.

If, however, you tried to lift the sledge hammer from the ground to a waist-high position, that would be another thing. You would be changing its rate of motion from zero to something higher. So you would have to overcome its inertia. There would be no sensation of weight as you lifted, yet the sledge hammer would move upward slowly. You would feel as though you were lifting it through something thick and sticky. Still, it would not be as hard to lift as on the earth's surface. There you would have to overcome inertia *plus* the pull of gravity.

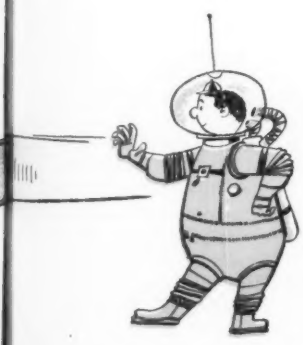
In lifting the sledge hammer on a space station, you'd get a real surprise when you tried to stop the sledge hammer's upward movement. On the surface of the earth, you would merely lift the sledge hammer to your waist, then stop lifting. At once, the sledge hammer would stop moving upward, thanks to the pull of gravity. There would be inertial resistance to the sledge hammer's stopping, but gravity would overcome it for you.

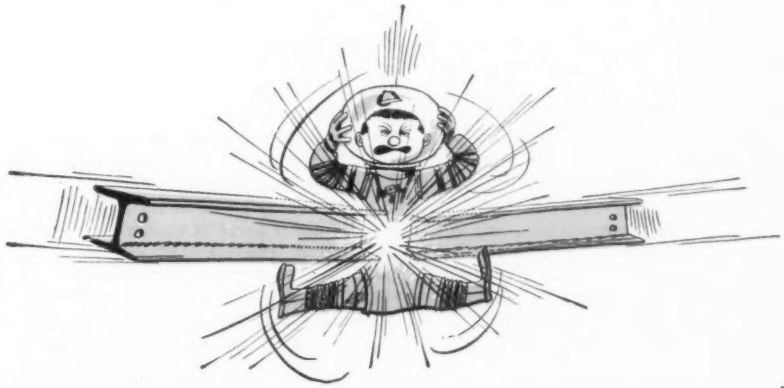
But on a space station, you would not have gravity helping you. If you lifted the sledge hammer to your waist and then stopped lifting, the sledge hammer would simply continue to move upward. You would have to fight to stop it, exerting just as much force in the process as you exerted to lift it in the first place. In fact, unless you were firmly attached to the space station, the sledge hammer would lift you with it. For gravity would not be holding you down.

Inertia could become deadly dangerous, if you let the feeling of weightlessness fool you into carelessness. In building a space station, you could move and maneuver large girders fairly easily. But once you got them moving briskly, they would be hard to stop. Two girders coming together at a great enough velocity would buckle. If a man were between the two girders, he would be crushed and killed, even though both girders together apparently weighed less than a feather.

When the day comes that construction work under low-gravity or non-gravity conditions becomes a recognized occupation, people planning to enter the field will probably have to undergo long and rigorous training. They will have to learn to pay no attention to weight and much attention to mass.

Many of us have a hard time visualizing the difference between mass and weight here on earth. But, out in space, the difference will become strikingly apparent.





Science in the news

Ten-year space plan drafted by NASA

At least one satellite or "deep" space probe will be launched every month in a comprehensive ten-year space program announced by the U.S. Government. The program, drafted by the National Aeronautics and Space Administration, will go into effect around midyear. The long-range plan also includes the firing of 100 sounding rockets a year. These will investigate the nature of the earth's atmospheric blanket. Some will travel to distances of about 4,000 miles.

The United States will need from eighteen months to two years to put a vehicle into space that can equal the weight of the Russian Lunik, stated T. Keith Glennan, head of the NASA. The space administrator said that the ten-year plan would implement an "urgently needed sustained effort" in space technology. The program is divided into five research areas:

Atmosphere. There will be an intensive investigation of the atmospheres of the earth, planets, moon, and sun. Scientists know that up to 250 miles the earth's atmosphere is highly variable. They'll try to find out just how atmospheric conditions vary with location, night and day, and the solar sunspot cycle. They'll also explore relationships between atmospheric conditions and the earth's weather patterns, solar and cosmic radiation, and the newly discovered double band of earth-circling radiation. By deep space probes, some going millions of miles, they will attempt to find out how far the sun's atmosphere extends. They'll test a current theory that the earth is orbiting through the sun's atmosphere. Probes also will be used to discover whether the moon has some kind of surface atmosphere.

Ionosphere. Researchers during the past twelve years have pieced together a fairly complete picture of this electrically charged atmospheric layer of the earth—but only up to about 60 miles. Now probes will explore its character at from 60 to 150 miles and higher.

Energetic particles. Fast-moving electrons, protons, and cosmic rays that interact with the earth's atmosphere will be studied. Scientists are particularly interested in their composition, origin, and source. Satellites and space probes will be used to learn more about the earth-circling double radiation band and the particles it contains.

Fields in space. Magnetometers will be used in rockets and satellites to study variations in the earth's magnetic field and in the fields of the sun, moon, and planets. The instruments will also be used to determine whether electrical currents surround the earth above the ionosphere, as they do in and beneath the ionosphere. In addition, scientists will try to learn how gravity is produced, what is the source and unit of its energy, and how fast its energy travels.

Astronomy. A brand-new look at the sun and stars will be provided by rockets and satellites. They will be equipped to observe the stars' signals – ultraviolet radiation, X rays, and radio waves. Normally, these signals can't be received on earth because they are absorbed by the earth's blanket of atmosphere.

NASA officials hope the ten-year program will supply answers to these puzzling questions about the universe:

Would Newton's apple fall at the same rate in the outermost regions of the universe?

What is the origin of the mysterious, powerful cosmic particles that bombard our earth?

Would an atomic clock in a satellite run slower than a similar one on earth, as Einstein predicted? (According to the theory, time passes more slowly on a faster-moving object than on one that moves more slowly.)

Is the earth enveloped in the sun's atmosphere? If so, how does this affect our weather? (A "yes" answer would enable scientists to account for much of the heat received by the earth.)

Engineers plant odd crop — it can't be eaten

Engineers at Bell Telephone Laboratories recently supervised some winter planting in eleven acres of fertile Georgia soil. Though their crop isn't edible, it will give them something to "chew on." It consists of nearly 11,000 pieces of telephone equipment – wires, cables, and so forth – buried in the earth.

This equipment will be dug up after periods of from one to thirty-two years. Bell engineers will then test the equipment to determine how it has survived the rigors of dampness and of high biological activity common to the soil in this and other areas. A similar test will be made in the alkaline soil of the Southwest.

If the equipment bears up well in these burial tests, company officials will consider the possibility of running telephone lines underground in many parts of the country. Reason: to escape the damage done to aboveground poles, wires, and other equipment by high winds and ice storms.

Off they'll go into the wild blue aerospace

The earth's atmosphere plus outer space equals aerospace. This new addition to our space-age vocabulary has been suggested by the Air Force. Since no natural barrier or dividing line separates the earth's atmosphere from outer space, an Air Force official says, the two words should be combined into one word. Air and space comprise one single operational field in which we function, added the official.

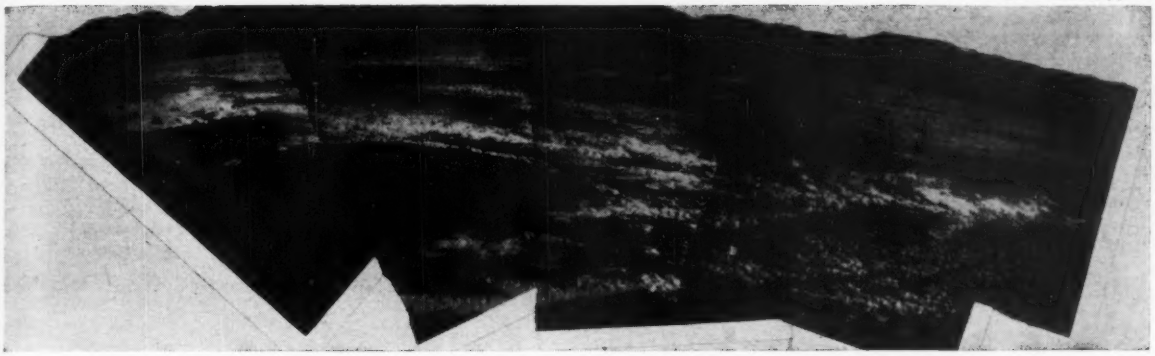
Wheel-less car shown at Chicago auto show

They're not for sale – yet – but a wheel-less automobile and one with a motor for each wheel were recently shown to the public at a Chicago auto show.

Called Glideair, the wheel-less car is really a scooter levitated on air. A jet of compressed air holds the scooter and its passengers a fraction of an inch above the ground, while propelling the scooter in any direction. A perforated steel disk releases the compressed air that raises the vehicle above the roadbed. Officials of the Ford Motor Company, maker of the experimental vehicle, think it could be developed to travel at speeds of from 200 to 500 miles an hour. Obviously, a safer highway system would be required for cars traveling at such speeds.

A less radical departure from today's cars is the motor-for-each-wheel model exhibited by the De Soto Division of Chrysler Corporation. Smaller than a standard automobile, it looks like a highly streamlined version of a present-day car. But its primary source of power comes from the chemical interaction of hydrogen and oxygen. The gases are fed into four cells, each near a wheel. Energy from the interaction of the gases is converted directly into electricity. This powers four high-speed, lightweight traction motors, one geared directly to each wheel. The advantages of such a car would be no motor noise and, as a result of fewer moving parts, simpler maintenance.

—Official U. S. Navy photo



The Atlantic from Maine to Florida is shown in this extraordinary photograph taken with a wide-angle movie camera from a rocket 86 miles in the sky. Span of horizon is 1,500 miles. Dense band of clouds in right foreground is storm front 700 miles long. A major breakthrough in meteorology, rocket photography will be invaluable for spotting and observing storms and hurricanes.

Earth is pear-shaped, satellite data shows

The earth is not a slightly flattened sphere, as we thought it was. Instead, it is shaped somewhat like a fat pear. To get the picture, first imagine the earth as a perfect sphere. Flatten it very slightly at the poles. Then pinch it in very slightly in the Northern Hemisphere.

Scientists were able to draw this new picture of the earth by observing the orbit of the tiny Vanguard satellite. As the satellite goes around the earth, it sometimes wobbles in its orbit. These wobbles are caused by changes in the pull of gravity brought about by humps and depressions in the globe. By charting these humps and depressions, scientists came up with the pear-shaped picture of the earth.

Our planet's new look is of great significance to geologists. It means that the earth's rock interior is much stronger than they had supposed. Otherwise, the earth could not withstand the strains imposed by the newly found bulges and depressions.

Lightning set off by cloud-seeding test

Seeking a way to reduce lightning and hail, researchers at the University of Arizona tried cloud-seeding. They were surprised to find their plan worked in reverse — at least as far as lightning was concerned. Seeding with silver iodide (commonly used in rain-making experiments) increased the amount of lightning by nine times.

On days that clouds were seeded, observers recorded 1,265 flashes of lightning. On days when clouds were not seeded, only 138 flashes were reported. More rain fell on seeding days, but the extra rainfall wasn't enough to prove that seeding was responsible. Researchers agreed that seeding caused faster cloud growth and a release of latent heat. But why it caused lightning to increase remains a mystery.

Volcano on moon? Scientists disagree

Most of the world's scientists were skeptical when a Russian scientist recently announced his discovery of a volcanic eruption on the moon. Now evidence submitted by the scientist, Dr. Nikolai A. Kozyrev, has convinced at least some of them that his observations were correct.

Though the Russian's finding may be argued for some time, it is bound to affect astronomical theory. Astronomers have been watching the moon through telescopes for 350 years. But never before have they observed any activity there. So they naturally assumed that the moon was a completely inactive body. The moon's craters, they theorized, were caused by the impact of giant meteorites. Now some doubt has been cast on this theory.

Most scientists agree that Dr. Kozyrev's evidence shows for the first time that there is activity on the moon. But some scientists doubt that the activity is volcanic in nature. What the Soviet scientist observed, they believe, was an escape of gases from beneath the moon's surface. Rays from the sun could have caused the gases to glow, giving the impression of a volcano.

News in brief

● Five minute *Neopilina*, ancestors of the snail, have been dredged up from three miles down in the Pacific Ocean off Peru. The find, by Columbia University geologists, is in a sense comparable to finding a dinosaur that was recently alive. Previously, scientists thought *Neopolina* had been extinct for some 300 million years. The specimens — less than 1/10 inch in diameter — were scraped alive off the ocean bottom, but all five died before they reached the ocean's surface. Drastic changes in temperature and water pressure caused their death.

● Though the first U.S. manned-space-capsule flight is two years off, the pilot is already being trained. He's one of 110 candidates chosen by the National Aeronautics and Space Administration. Intensive physical and psychological tests will narrow the list until the actual candidate is selected just before the first orbital flight. The pilot will be younger than 40, no taller than 5 feet 11 inches, and will have outstanding physical and psychological qualifications. He will hold a degree in physical science or engineering, will be a graduate of a military test-pilot training school, and will have a minimum of 1,500 hours of flight time.

● Steps are being taken to lessen the problems of electric power companies — while lengthening the life expectancy of squirrels. Squirrels and some other animals have a disconcerting habit of scrambling atop distribution transformers and pressing their noses against high-voltage wires. Besides doing irreparable damage to the squirrels, this interrupts power transmission and increases the work-load of maintenance crews. Future transformers will be insulated with a special plastic coating. They will give an adventuresome squirrel only a discouraging tickle.

Young scientists

Logical circuitry and symbolic logic

Circuits with built-in 'reasoning' are the basis of modern computing machines.

Here are some simple circuits you can experiment with and combine into puzzle-solving machines

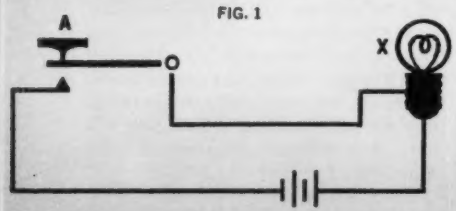
■ Can scientists make machines that think? It is scarcely likely that we shall ever construct a machine that can do all the kinds of thinking that a human brain can. But machines that can do particular kinds of calculating faster and more accurately than man are beginning to play an important part in our quest for knowledge. Such machines can, in the twinkling of an eye, make computations that would take human mathematicians days or perhaps years.

Computers handle numbers and operate in accordance with a fixed set of rules developed by mathematicians. The basic circuit of computers is shown in Fig. 1. It is known as the "yes-no" circuit. By adapting this circuit mechanically or electrically and coupling it with a mathematical system involving binary numbers, we can perform mathematical computations with amazing rapidity. Perhaps in a later article we shall discuss such computers, but for now let us concern ourselves with this question: can a machine be built to handle the relationships of ideas or groups of ideas rather than numbers? For this purpose the logician, the mathematician, and the physicist joined forces. The logician explored the principles by which — given a set of ideas or circumstances — we arrive at valid conclusions. The mathematician then took these principles and developed techniques by which we could quickly determine all the possible conclusions from a given set of circumstances. The physicist translated the work of the mathematician into machines that, if fed bits of information, arrived at valid conclusions quickly and accurately.

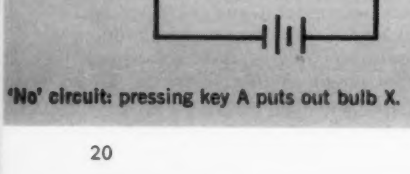
Let's take a simple illustration. Suppose that your teacher says to you, "If you bring your books and pencils, you will receive extra credit." Now analyze this sentence and see exactly what the teacher means. Suppose you brought only your books. Obviously, since the conditions set were that you bring both your books and your pencils, your books alone would not get you extra credit. Similarly, no credit would be forthcoming if you brought only the pencils. If you brought neither books nor pencils, you certainly would not get extra credit. We have now analyzed all the possibilities in a logical way.

What kind of a machine can do the same type of analysis? Examine Fig. 2. This machine can deal with any situation that presents conditions similar to those in the statement, "If you bring your books and your pencils you will get extra credit." Let *A* represent the books, *B* the pencils, and *X* the sought-after extra credit. "If you bring your books (*press key A*) and you bring your pencils (*press key B*) you will get

FIG. 1



'Yes' circuit: pressing key A lights bulb X.



'No' circuit: pressing key A puts out bulb X.

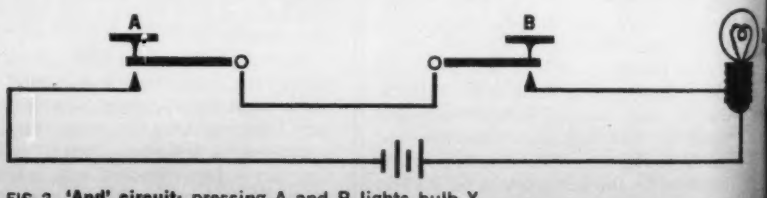


FIG. 2 'And' circuit: pressing A and B lights bulb X.

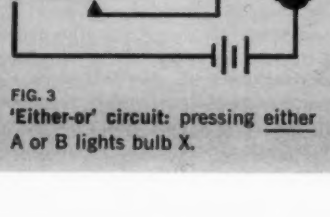


FIG. 3
'Either-or' circuit: pressing either A or B lights bulb X.

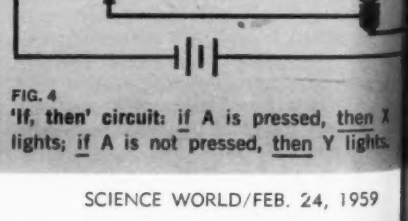


FIG. 4
'If, then' circuit: if A is pressed, then X lights; if A is not pressed, then Y lights.

extra credit (*bulb X lights up*)." Now try the other possibilities. Pressing either key *A* or *B* (bringing either books or pencils) will not light bulb *X*. Only when both *A* and *B* are pressed does the desired result (extra credit) occur. Here we have a circuit that represents a logical statement and enables us mechanically to ascertain the truth of all the combinations. You can probably see why the circuit of Fig. 2 is called an "and" circuit.

Now see how some of the other simple circuits drawn below represent other types of logical statements. Try this one: "If you return either the red book or the blue book or both, I will refund your money." This statement is represented by Fig. 3, the "either-or" circuit. Key *A* represents the red book and key *B* the blue. Pressing (returning) either one or both keys lights the bulb (gets you the refund).

Suppose, however, the statement was: "If you return either the red book or the blue book, but not both, I will refund your money." Fig. 5 is an "either but not both" circuit. Pressing either *A* or *B* (returning either the red or the blue book) lights the bulb *X* (gives you the refund). Pressing both, however, does not light the bulb (no refund).

Try your hand at setting up statements represented by the circuits in Figs. 4 and 6.

In dealing with logical circuitry (circuits that solve logical problems), mathematicians had to develop a shorthand way of stating conditions. They devise a set of symbols for the key words in a logical statement. For example the symbol $\wedge$ stands for "and," $\vee$ means "or," $\supset$ means "if . . . then." Capital letters stand for conditions. Thus, $A \wedge B \supset X$ is the shorthand way of saying, "If A and B, then X follows." A bar over a letter means "not." Thus $\overline{X}$ means "not X."

If you examine the circuit in Fig. 2 you will find that the following conditions obtain: $A \wedge B \supset X$, $A \wedge \overline{B} \supset \overline{X}$, $\overline{A} \wedge B \supset \overline{X}$. The circuit in Fig. 3 can be expressed by: $A \wedge B \supset X$, $A \vee B \supset X$. See if you can write the "equations" for the conditions of the circuits in Figs. 4, 5, and 6 below.

Another task of the mathematicians was to find ways in which such equations could be manipulated. For this purpose they use a type of algebra called Boolian algebra (named after the man who invented it). Perhaps in your later work in mathematics you may learn more about it.

By now, you may be wondering who would want to use a machine for such simple kinds of reasoning. It is when we have combinations of ideas that machines can outrace the human mind, arriving at conclusions quickly and without error.

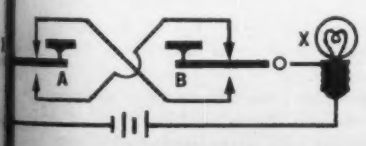
A machine that's fun to build and use is the one illustrated in Fig. 8. It represents a famous puzzle. A farmer wants to ferry a fox, a goat, and a head of cabbage across a stream in a small boat, which can hold only himself and one of his possessions. Obviously, he must never leave the goat and the cabbage alone or the fox and the goat alone. In this machine, toggle switches are flipped to denote the crossing of the river. If a mistake is made in the sequence of crossings, the bulb lights. The aim of the game is to flip a switch or a pair of switches in the proper order to get all four items across the river without the trouble light flashing to tell you an error has been made.

If you examine the circuit of this machine, you will notice the use of "either-or," "either but not both," and "if . . . then" circuits. All the conditions of the problem are built into the machine. While you are playing the game, the machine quietly checks your every move, waiting for you to make a mistake. And it will tell you when you have made the mistake faster than you can realize it.

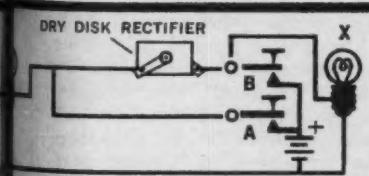
Logic machines can be fun to experiment with. Study each of the basic circuits below. Try them in various combinations. You might even want to add the "remember-forget" circuit of Fig. 7. To combine circuits, simply remove the bulb from the first circuit and the battery from the second. Connect two wires from the bulb contacts of the first circuit to the wires that were connected to the battery of circuit two. The results of such combinations can get very complex. For example, combining the circuit of Fig. 3 with that of Fig. 5 gives us the following conditions: if *A* or *B* of *3* and *A* or *B* of *5*, then *X*; if *A* and *B* of *3* and *A* or *B* of *5*, then *X*. See if you can phrase a logical statement for which this machine has all the answers.

— THEODORE BENJAMIN

— Drawings by LoCurcio

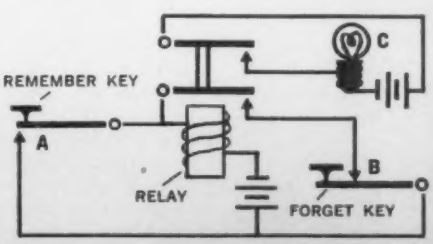


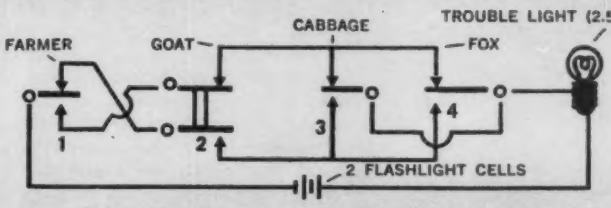
5 **'Either but not both' circuit:** if either A or B is pressed, X lights; but if both A and B are pressed, X does not light.



6 **'And-but not' circuit:** when A is pressed, X and Y light; when B is pressed, X but not Y lights; Y is never on alone.

FIG. 7
'Remember-forget' circuit: When A is pressed, the relay trips, and C lights. Long after A is released C remains lit. Pressing key B causes C to go out, and the circuit 'forgets' that A was pressed.





1, 3, and 4 are single-pole, double-throw toggle switches. 2 is a double-pole, double-throw toggle switch.

FIG. 8 **This simple circuit, which you can build, illustrates how a machine can handle a logical problem—the famous farmer, goat, cabbage, and fox problem.**

Gary Mims of Canadian, Texas, writes:

Does it ever get too cold to snow?

No. Snow is always possible, because air contains moisture no matter how cold it becomes. Water falls out of very cold air in the form of small, dry snow crystals. (Large, soggy flakes are the result of crystals falling through low, moist segments of air.) You often hear people say it's too cold to snow. They've jumped to this conclusion because cold air from northerly latitudes usually is accompanied by general clearing conditions brought on by high-pressure areas. Heavy snows, on the other hand, are associated with the milder air in advance of a warm front.

Don Engstrom of Worcester, Massachusetts, writes:

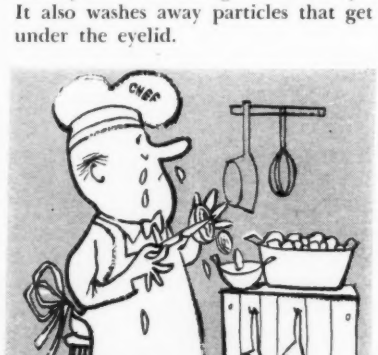
Is it true that dogs can see only black and white?

Not quite. Dogs can see shades of gray, too. A dog's vision can be compared to black and white photography. The canine sees color — from the brightest hues to the dullest — only as varying intensities of gray. Like dogs, most other mammals are color blind. A notable exception: the ape.

William Schreffler of Thompsonville, Connecticut, writes:

How and why does salt form in our tears?

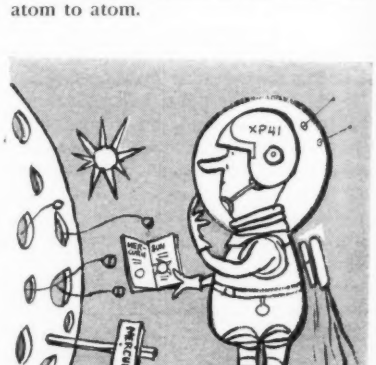
It's quite natural for our tears to be salty. For salt is always present in our body's cells and fluids. It is indispensable to our body's welfare, especially in helping to keep our nerves and muscles in proper working order. Tears are simply an excess of the salty fluid that lubricates the eye. This fluid is secreted from our blood by the lachrymal gland of the eye. About a dozen short ducts carry the fluid from the gland to the undersurface of the upper eyelid. Each time the lid is dropped, it sweeps the front of the eye, bathing its surface and keeping it moist. The fluid protects the eye's delicate surface and facilitates clear vision. It contains a substance known as lysozyme, which destroys bacteria that get into the eye. It also washes away particles that get under the eyelid.



Doug Kausek of Columbus, Ohio, writes:

What is electricity?

Though it's possible to describe how electricity behaves and what it does, no one knows what it really is. Electrical forces exist in the atoms that make up matter. In the center (or nucleus) of each atom are tiny particles called *protons* and *neutrons*. Protons have or are positive electrical charges. Neutrons are neither positively nor negatively charged. Revolving around the nucleus of the atom are *electrons*, which are negative electrical charges. Ordinarily, the negative electrons balance or equal the positive protons. But some types of atoms tend to lose or gain outer electrons — copper atoms, for instance. Electrons that have been freed from the atoms of a copper wire can be made to move freely through the wire from atom to atom. This movement of electrons is known as electricity. A battery or generator provides electrons that will start the movement of the electrons in the wire from atom to atom.



Joseph Bitetto of Brooklyn, New York, writes:

Since the planet Mercury is so near the sun, why doesn't it burn?

Mercury, the planet nearest the sun (28,600,000 miles at its closest point), cannot be burned by the sun's rays because it has no atmosphere. Burning is a chemical action that requires oxygen (or some other oxidizer). Without atmosphere, there is no oxidizer and, consequently, no burning. On Mercury's "sunward" side, temperatures reach 770°F. But on the side turned away from the sun, since there is no atmosphere to transfer heat, temperatures are close to absolute zero.

Questions from readers will be answered here, as space permits. Send to: Question Box, Science World, 575 Madison Avenue, New York 22, N.Y.

Careers

CORROSION FIGHTERS

■ Corrosion engineer Bill Ashbaugh put down the phone and turned to his assistant. "Mick," he said, "I just got a call from a worried department head who says we steered him wrong on that last batch of replacement bubble caps — says some of them aren't holding up the way we said they would."

The two men went out into the maze of piping, columns, and reaction kettles that represent a modern chemical industrial plant. They stepped into the unit supervised by the worried caller.

The department head showed them several trays of bubble caps in a distillation column. The caps, vital components in the chemical distillation process, are small metal objects that look like inverted coffee cups with slotted sides. They are placed on trays at various levels inside a column. Vapors from the liquid being fractionated bubble up through the caps and escape through the slots, rising to a higher level. The liquid left on the tray is collected as a purified fraction of the raw stock.

The corrosion men — or materials engineers, as they are sometimes called — saw that some of the caps on a tray were badly corroded; but others were perfectly good. "Looks as if we have a mixture here," said Bill. "It's apparent that the metals in the caps differed in some way — let's give them a good checkup."

On the same tray good and bad caps were scattered with no special geometric design, and the attack was not confined to one tray or location in the column. Obviously the corrosion was not caused by localized flows or temperatures and pressures around the caps, nor could the process liquid be blamed for the spotty attacks.

Bill and his chief assistant engineer, Mick Rodgers, gathered samples of the caps — good and bad — and carried them back to their lab. There they ran chemical tests. Results: negative. The alloys seemed the same in good and bad caps.

In the lab they cut out sections of the metal from good and bad caps. The cross sections were polished and treated with acid to bring out the grain structure. Then they were placed under the high-power metallurgical microscope.

Bill peered at the enlarged picture — and there he saw differences between the good and bad caps.

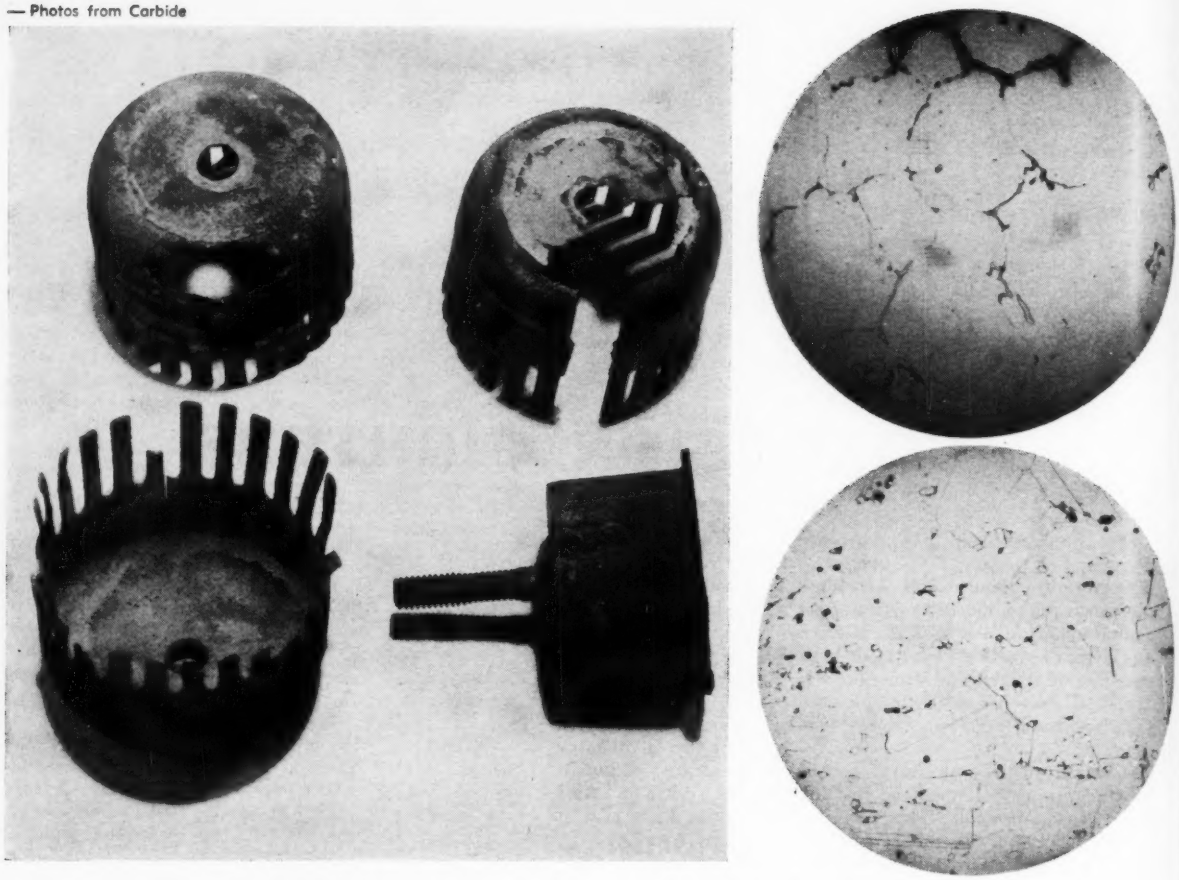
But how could that be? The caps were made of the same alloy, at the same time, and by the same fabricator. Yet the microscope showed smooth normal grain in the good cap and rough irregular grain in the bad cap.

It meant the history of the caps had to be traced to the beginning. The materials engineers went to the people who made the caps.

On the production line they found the answer. To make the caps the metal had to be heated several times in the process of fabrication. *And some of the caps had been overheated.* The overheating had caused changes in the metal — not apparent to the naked

Powerful metallurgical microscope is one of Bill Ashbaugh's most important tools.

— Photos from Carbide



Bad bubble caps taken from tray looked like those shown in photo left. The trouble lay in abnormal grain structure, which showed up in photomicrograph (*top right*). Photomicrograph (*bottom right*) shows smooth normal grain structure.

eye — which made the metal more susceptible to corrosion. It was these caps that had failed in the distillation column.

This meant, then, that the good caps on the trays in the column were good for many more months of service and the bad caps merely needed replacement.

It also meant their original judgment in recommending the alloy for that chemical process was good. Back in service, the distillation column has operated at high production for many months — with the prospect of years more of continuous service.

Bill Ashbaugh chalked up another "satisfied customer" for the Materials Group.

This organization in the Texas City, Texas, plant of Union Carbide Chemicals Company (division of Union Carbide Corporation) is responsible for the selection of proper materials of construction and for prolonging equipment life through corrosion control.

It's a big job.

Everybody knows about rust — how it will damage metal. Rust is the most familiar form of corrosion, one that has troubled man ever since the savage hammered out weapons from basic metals. But, except for painting and galvanizing, modern man has not undertaken scientific investigation of the problem until relatively recently.

It was World War II that branded corrosion as a villain costing plenty of money each year. In 1945, the National Association of Corrosion Engineers was formed in Houston, with membership of about 250 persons. The organization was designed to make corrosion studies on a national scale and to pool information on the subject.

The facts they came up with were eye-openers. For instance, in 1950 a survey showed the annual cost to the United States directly due to corrosion was a staggering *six billion dollars*. Take the little item of automobile mufflers, for example, which are made useless through corrosion. In 1946, 7,840,600 mufflers were installed by car dealers and independent garages. At ten to fifteen dollars for each job, it amounts to over a hundred million dollars.

What are Bill and the other materials engineers doing to combat this attack?

Basically, there are four courses open to them when they discover a piece of equipment has failed due to corrosion.

1. They can recommend a new alloy. For example, stainless steel is an alloy of steel that resists corrosion better than plain steel. Copper alloy used in water pipes lasts longer than steel, as homeowners have found out.

2. They can recommend a change in operating conditions. Heat, pressure, and types of liquids flowing through unit equipment affect the rate of corrosion. Sometimes it is possible to change operating conditions to lower the corrosion rate without affecting the rate of production.

3. They can inhibit the environment. A good example of this: car

radiators, where rust inhibitors are added to the cooling water to retard the rate of corrosion that means costly repairs to the car owner.

4. They can isolate the metal from the environment. That's a fancy way of saying that painting or coating of metal surfaces will help keep the metal from corroding.

The decisions that Bill and his colleagues make are governed by economic laws. You could build an entire plant out of gold, stainless steel, silver, or some other metal that naturally resists corrosion. But the costs of construction would never be repaid through production even if the plant stood up a hundred years.

What they have to do is protect the cheaper materials or figure out where more costly metals can be used economically.

Many times, the materials engineers have to spend considerable time and study to lick a problem of corrosion. Other times, it is simple — like the time a one-inch copper line failed soon after it was put in service carrying river water. This was contrary to normal experience, and Bill was called in on the case. Examination of the inside of the pipe showed deep grooves and ridges.

Bill came up with a quick solution on this one. "Replace the one-inch pipe with two-inch," he said.

It worked. The problem was corrosion and erosion. The one-inch line was too small to carry the load, and it caused an extra-fast flow of water through the pipe. Just as a high-pressure hose will eat holes in a mudbank, the fast-flowing water cut grooves in the pipe and hastened corrosive action.

But other problems are not so small or so quickly solved. Union Carbide operates a tanker between New York and Texas City that carries many different kinds of liquids on each trip. The corrosion problem was terrific. The ballast tanks were the big headaches. During the trip north the tanks were filled with refined products, and on the return trip they were filled with sea water to maintain proper trim on the tanker.

Bill and his crew worked for years on this problem. They kept scientific controlled tests going for months just to find where and when corrosion took place at the fastest rates.

They found that rusting took place fastest when the tanks were filled with chemicals or were empty. The salt-water ballast caused corrosion at a much slower rate.

So they tried many remedies. They painted the tanks — too expensive. They tried cathodic protection to fight corrosion with corrosion — too inefficient. They tried adding a small amount of inhibitor to the gasoline-filled tanks and sprayed the empty tanks with another inhibitor. It worked.

Now the corrosion problem on the tanker *R. E. Wilson* has been brought down to normal proportions. Result: hundreds of thousands of dollars saved over the life of the ship.

This business of scientific corrosion fighting is a new one. Almost every engineer and scientist working on materials problems entered the field with a background of either metallurgy, physics, or some other branch of engineering. Even today there is no college that grants a degree specifically in corrosion engineering.

Bill Ashbaugh started out in chemistry. He was graduated from Albion College in Michigan in 1948 with a degree in chemistry. He worked two summers at General Motors, where he was introduced to the complexities of metals.

Then he came to Union Carbide in Texas City. As a chemist, he was assigned to the specific problems group in the works laboratory. Probably because of his background in metals, one of the first problems assigned him was the reconstruction of an acid unit. On the premise that weak sulfuric acid is non-corrosive to copper, the unit had been built primarily of copper. But all oxygen cannot be excluded from the process, and in the presence of oxygen the copper failed dramatically. Bill and another converted chemist, Paul Dillon, gathered much information from the failure and came up with an alloy that has licked the problem.

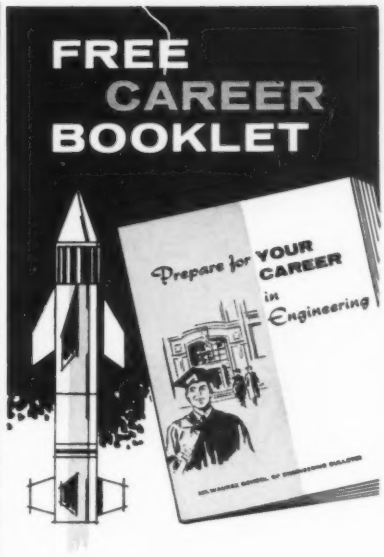
That experience and success whetted Bill's interest in the field of corrosion. Soon all the rust problems were thrown Bill's way and a materials group was formed.

There was little data on corrosion in the textbooks, but Bill dug in. He attended short courses at universities. He joined corrosion organizations. He performed experiments. He developed new techniques and procedures for tracking down and cataloguing various types of corrosion.

In a few years he has come to be one of the recognized experts in the field of corrosion in the chemical industry. University professors come to him for aid and advice in some of their experiments.

Bill has the scientist's curiosity. He has the scientist's attitude of never jumping to conclusions based on scanty evidence and experimentation.

And he loves his work. It's new — it's challenging. To most people a pile of rust is an ugly thing. To Bill it's beautiful.



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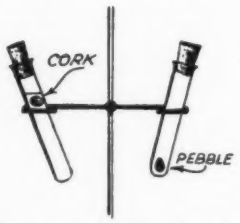
High School (Name) .....
Will Graduate (Year) .....

On the light side

Brain teasers

The cork and the rock



The test tubes in the above picture are filled with water and firmly stoppered. A cork ball floats in one tube, a pebble rests on the bottom of the other. If the tubes are whirled rapidly around the vertical bar, what happens to the cork and the pebble?

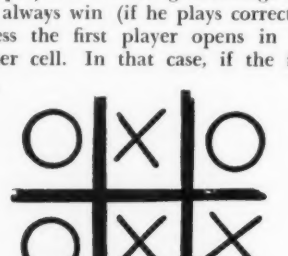
Second child

Mr. Johnson has two children, and at least one of them is a boy. If you were to guess the sex of the other child, which sex would you choose?

Reverse ticktacktoe

A mathematical game can sometimes be reversed so that the object of play is to force the other player to win. This usually results in a surprisingly different mathematical structure. Give-away checkers is a familiar example. Less well known is the reverse form of ticktacktoe. In this, the first player to get three marks in a row *loses*.

Reverse ticktacktoe is more complicated than the regular game. The second player has a strong advantage and can always win (if he plays correctly), unless the first player opens in the center cell. In that case, if the first player always takes a cell directly opposite his opponent's last move (so that three marks are in a line) the game is sure to end in a draw, as in the one shown.



The best plan to follow in playing against someone who does not know the symmetry strategy just explained is to play each time so that you leave your opponent a maximum number of ways to win. Try a few games, and see how much fun it is.

Super-strength

Do you know that there is a simple way to break even the strongest cord or fishline with your bare hands? It is both an entertaining demonstration of super-strength and a highly useful thing to know.

Wrap one end of the cord around your left forefinger, then loop it around the hand exactly as shown. With your other hand, seize the cord a foot or two below, wrapping it several times around the right hand. Close both hands into fists. Hold the fists close together, then quickly yank your right fist down and your left fist up. The cord will snap inside your left fist at the point marked *A*.

The feat illustrates the fact that *pressure* is the *force* divided by the *area* on which the force operates. By looping the cord as shown, the force is concentrated on the tiny area where the cord intersects itself. This raises the pressure enough so that the cord acts like a dull knife blade and literally cuts through itself.

The invisible leg

Cold winter days, when the air inside is dry and warm, are ideal for experiments with static electricity. Here is an unusual one.

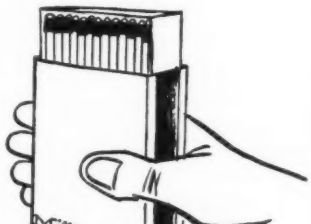
Press the toe of a nylon stocking against the wall. With the other hand, stroke the stocking vigorously several times with a transparent polyethylene vegetable bag. (If you can stretch the material of the bag you know it's polyethylene.)

Now hold the stocking in the air and see how it fills out as though an invisible leg were inside. The effect is due to a strong static charge on the nylon. Because like charges repel each other, the sides of the stocking billow as far apart as possible.

Matchbox stabilizer

Challenge someone to hold a box of matches (the type with a sliding drawer) a foot above the table, then drop it so it lands on one end and remains standing. When he tries it, the box will bounce and land on its side.

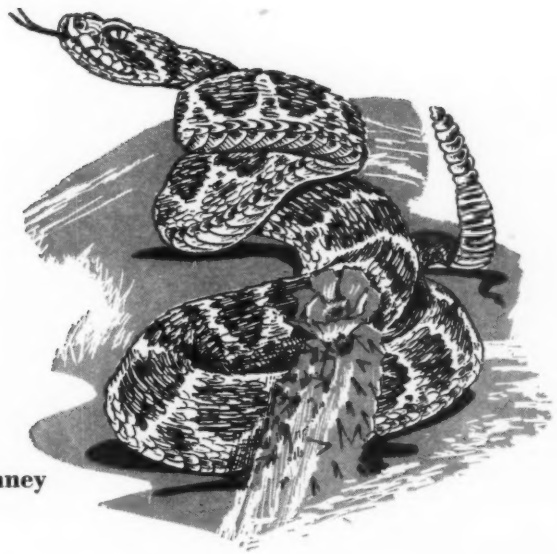
The trick is to take advantage of the stabilizing power of momentum (speed times mass). Push the drawer about an inch out of the cover, then drop the box, as shown. When it hits the table, the momentum of the drawer sliding shut will prevent the box from falling over. Gyroscope stabilizers in airplanes, torpedoes, and guided missiles operate on the same basic principle. The only difference is that, in these, the momentum is created by rapidly spinning wheels. — GEORGE GROTH



Answers

THE CORK AND THE ROCK: Centrifugal force will cause the pebble to rise and the cork to sink. The cork sinks because the water is forced upward in the tube with greater force than the cork.

SECOND CHILD: Your best guess would be that the other child is a girl. There are three equally possible cases: (1) boy and younger sister, (2) girl and younger boy, (3) two boys. In only one case is the other child a boy. So the odds that it is a girl are two to one.



By Charles G. Finney

The life and death of a western gladiator

Science fiction

■ He was born on a summer morning in the shady mouth of a cave. Three others were born with him, another male and two females. Each was about five inches long and slimmer than a lead pencil.

Their mother left them a few hours after they were born. A day after that his brother and sisters left him also. He was all alone. Nobody cared whether he lived or died. His tiny brain was very dull. He had no arms or legs. His skin was delicate. Nearly everything that walked on the ground or burrowed in it, that flew in the air or swam in the water or climbed trees was his enemy. But he didn't know that. He knew nothing at all. He was aware of his own existence, and that was the sum of his knowledge.

The direct rays of the sun could, in a short time, kill him. If the temperature dropped too low he would freeze. Without food he would starve. Without moisture he would die of dehydration. If a man or a horse stepped on him he would be crushed. If anything chased him he could run neither very far nor very fast.

Thus it was at the hour of his birth. Thus it would be, with modifications, all his life.

But against these drawbacks he had certain qualifications that fitted him to be a competitive creature of this world and equipped him for its warfare. He could exist a long time without food or water. His very smallness at birth protected him when he most needed protection. Instinct provided him with what he lacked in experience. In order to eat he first had to kill; and he was eminently adapted for killing. In sacs in his jaws he secreted a virulent poison. To inject that poison he had two fangs, hollow and pointed. Without that poison and those fangs he would have been among the most helpless creatures on earth. With them he was among the deadliest.

He was, of course, a baby rattlesnake, a diamondback, named *Crotalus atrox* by the herpetologists Baird and Girard and so listed in the *Catalogue of North American Reptiles* in its issue of 1853. He was grayish brown in color, with a series of large, dark diamond-shaped blotches on his back. His tail was white with five crossbands. It had a button on the end of it.

Little Crotalus lay in the dust in the mouth of his cave. Some of his kinfolk lay there, too. It was their home. That particular tribe of rattlers had lived there for scores of years.

The cave had never been seen by a white man.

Sometimes as many as two hundred rattlers occupied the den. Sometimes the numbers shrank to as few as forty or fifty.

The tribe members did nothing at all for each other except breed. They hunted singly; they never shared their food. They derived some automatic degree of safety from their numbers, but their actions were never concerted toward using their numbers to any end. If an enemy attacked one of them, the others did nothing about it.

Young Crotalus's brother was the first of the litter to go out into the world and the first to die. He achieved a distance of fifty feet from the den when a Sonoran racer, four feet long and hungry, came upon him. The little rattler, despite his poison fangs, was a tidbit. The racer, long skilled in such arts, snatched him up by the head and swallowed him down. Pow-

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erful digestive juices in the racer's stomach did the rest. Then the racer, appetite whetted, prowled around until it found one of Crotalus's little sisters. She went the way of the brother.

Nemesis of the second sister was a chaparral cock. This cuckoo, or road runner as it is called, found the baby amid some rocks, uttered a cry of delight, scissored it by the neck, shook it until it was almost lifeless, banged and pounded it upon a rock until life had indeed left it, and then gulped it down.

Crotalus, somnolent in a cranny of the cave's mouth, neither knew nor cared. Even if he had, there was nothing he could have done about it.

On the fourth day of his life he decided to go out into the world himself. He rippled forth uncertainly, the transverse plates on his belly serving him as legs.

He could see things well enough within his limited range, but a five-inch-long snake can command no great field of vision. He had an excellent sense of smell. But, having no ears, he was stone deaf. On the other hand, he had a pit, a deep pockmark between eye and nostril. Unique, this organ was sensitive to animal heat. In pitch blackness, Crotalus, by means of the heat messages recorded in his pit, could tell whether another animal was near and could also judge its size. That was better than an ear.

The single button on his tail could not, of course, yet rattle. Crotalus wouldn't be able to rattle until that button had grown into two segments. Then he would be able to buzz.

He had a wonderful tongue. It looked like an exposed nerve and was probably exactly that. It was forked, and Crotalus thrust it in and out as he traveled. It told him things that neither his eyes nor his nose nor his pit told him.

Snake fashion, Crotalus went forth, not knowing where he was going, for he had never been anywhere before. Hunger was probably his prime mover. In order to satisfy that hunger he had to find something smaller than himself and kill it.

He came upon a baby lizard sitting in the sand. Eyes, nose, pit, and tongue told Crotalus it was there. Instinct told him what it was and what to do. Crotalus gave a tiny one-inch strike and bit the lizard. His poison killed it. He took it by the head and swallowed it. This was his first meal.

During his first two years Crotalus grew rapidly. He attained a length of two feet; his tail had five rattles on it and its button. He rarely bothered with lizards any more, preferring baby rabbits, chipmunks, and round-tailed ground squirrels. Because of his slow locomotion he could not run down these agile little things. He had to contrive instead to be where they were when they would pass. Then he struck swiftly, injected his poison, and ate them after they died.

At two he was formidable. He had grown past the stage where a racer or a road runner could safely tackle him. He had grown to the size where other desert dwellers — coyotes, foxes, coatis, wildcats — knew it was better to leave him alone.

And, at two, Crotalus became a father, his life being regulated by cycles. His cycles were plantlike. The peach tree does not "know" when it is time to flower, but flower it does because its cycle orders it to do so.

In the same way, Crotalus did not "know" when it was time for young diamondback rattlers to pair off and breed. But his cycle knew.

Of the physical union six new rattlesnakes were born. Thus Crotalus, at two, had carried out his major primary function: he had reproduced his kind. In two years he had experienced everything that was reasonably possible for diamondback rattlesnakes to experience except death.

He had not experienced death for the simple reason that there had never been an opportunity for anything bigger and stronger than himself to kill him. Now, at two, because he was so formidable, that opportunity became more and more unlikely.

He grew more slowly in the years following his initial spurt. At the age of twelve he was five feet long. Few of the other rattlers in his den were older or larger than he.

He had a castanet of fourteen segments. Segments had been broken off occasionally in the past, but with each new molting a new segment appeared.

His first skin-shedding back in his babyhood had been a bewildering experience. He did not know what was happening. His eyes clouded over until he could not see. His skin thickened and dried until it cracked in places. His pit and his nostrils ceased to function. There was only one thing to do and that was to get out of that skin.

Crotalus managed it by nosing against the bark of a shrub until he forced the old skin down over his head, bunching it like the rolled top of a stocking around his neck. Then he pushed around among rocks and sticks and branches, literally crawling out of his skin by slow degrees. Wriggling free at last, he looked like a brand new snake. His skin was bright and satiny, his eyes and nostrils were clear, his pit sang with sensation.

For the rest of his life he was to molt three or four times a year. Each time he did it he felt as if he had been born again.

At twelve he was a magnificent reptile. Not a single scar defaced his rippling symmetry. He was diabolically beautiful and deadly poison.

His venom was his only weapon, for he had no power of constriction. Yellowish in color, his poison was odorless and tasteless. It was a highly complex mixture of proteids, each in itself directly toxic. His venom worked on the blood. The more poison he injected with a bite, the more dangerous the wound. The pain rendered by his bite was instantaneous, and the shock accompanying it was profound. Swelling began immediately, to be followed by a ghastly oozing. Injected directly into a large vein, his poison brought death quickly, for the victim died when it reached his heart.

At the age of twenty Crotalus was the oldest and largest rattler in his den. He was six feet long and weighed thirteen pounds. His whole world was only about a mile in radius. He had fixed places where he avoided the sun when it was hot and he was away from his cave. He knew his hunting grounds thoroughly, every game trail, every animal burrow.

He was a fine old machine, perfectly adapted to his surroundings, accustomed to a life of leisure and comfort. He dominated his little world.

The mighty seasonal rhythms of the desert were as vast pulsations, and the lives of the rattlesnakes were attuned to them. Spring sun beat down, spring rains fell, and, as the plants of the desert ended their winter hibernations, so did the vipers in their lair. The plants opened forth and budded; the den "opened," too, and the snakes crawled forth. The plants fertilized each other, and new plants were born. The snakes bred, and new snakes were produced. The desert was repopulated.

In the autumn the plants began to close; in the same fashion the snake den began to close, the reptiles returned to it, lay like lingering blossoms about its entrance for a while, then disappeared within it when winter came. There they slept until summoned forth by a new spring.

Crotalus was twenty years old. He was in the golden age of his viperhood.

But men were approaching. Spilling out of their cities, men were settling

A coyote was nothing that Crotalus feared. He had met — and dealt with — coyotes aplenty.

in that part of the desert where Crotalus lived. They built roads and houses, set up fences, dug for water, planted crops.

They homesteaded the land. They brought new animals with them — cows, horses, dogs, cats, barnyard fowl.

The roads they built were death traps for the desert dwellers. Every morning new dead bodies lay on the roads, the bodies of the things the men had run over and crushed in their vehicles.

That summer Crotalus met his first dog. It was a German shepherd which had been reared on a farm in the Midwest and there had gained the reputation of being a snake-killer. Black snakes, garter snakes, pilots, water snakes; it delighted in killing them all. It would seize them by the middle, heedless of their tiny teeth, and shake them violently until they died.

This dog met Crotalus face to face in the desert at dusk. Crotalus had seen coyotes aplenty and feared them not. Neither did the dog fear Crotalus, although Crotalus then was six feet long, as thick in the middle as a motorcycle tire, and had a head the size of a man's clenched fist. Also, this snake buzzed and buzzed and buzzed.

The dog was brave, and a snake was a snake. The German shepherd snarled and attacked. Crotalus struck him in the underjaw; his fangs sank in almost half an inch and squirted big blobs of hematoxic poison into the tissues of the dog's flesh.

The shepherd bellowed with pain, backed off, groveled with his jaws in the desert sand, and attacked again. He seized Crotalus somewhere by the middle of his body and tried to flip him in the air and shake him as, in the past, he had shaken slender black snakes to their death. In return, he received another poison-blurting stab in his flank and a third in the belly and a fourth in the eye as the terrible, writhing snake bit wherever it could sink its fangs.

The German shepherd had enough. He dropped the big snake and in sick, agonizing bewilderment crawled somehow back to his master's homestead and died.

The homesteader looked at his dead dog and became alarmed. If there was a snake around big enough to kill a dog that size, it could also kill a child and probably a man. It was something that had to be eliminated.

The homesteader told his fellow farmers, and they agreed to initiate a war of extermination.

The campaign during the summer was sporadic. The snakes were scattered over the desert, and it was only by chance that the men came upon them.

When autumn came the men decided to look for the rattlers' den and execute mass slaughter. The homesteaders had become desert-wise and knew what to look for.

They found Crotalus's lair without too much trouble — a rock outcropping on a slope that faced the south. Cast-off skins were in evidence in the bushes. Bees flew idly in and out of the den's mouth. Convenient benches and shelves of rock were at hand where the snakes might lie for a final sunning in the autumn air.

They killed the three rattlers they found at the den when they first discovered it. They made plans to return in a few more days when more of the snakes had congregated. They decided to bring along dynamite with them and blow up the mouth of the den so that the snakes within would be sealed there forever and the snakes without would have no place to find refuge.

On the day the men chose to return nearly fifty diamondbacks were gathered at the portals of the cave. The men shot them, clubbed them, smashed them with rocks. Some of the rattlers escaped the attack and crawled into the den.

Crotalus had not yet arrived for the autumn rendezvous. He came that night. The den's mouth was a shattered mass of rock. Dead members of his tribe lay everywhere. Crotalus nosed among them, tongue flicking as he slid slowly along.

There was no access to the cave any more. He spent the night outside among the dead. The morning sun warmed him and awakened him. He lay there at full length. He had no place to go.

The sun grew hotter upon him and instinctively he began to slide toward some dark shade. Then his senses warned him of some animal presence nearby; he stopped, half coiled, raised his head, and began to rattle. He saw two upright figures. He did not know what they were, because he had never seen men before.

"That's the grand-daddy of them all," said one of the homesteaders. "It's a good thing we came back." He raised his shotgun. ■

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The diverse opportunities for trained pharmacologists are discussed in a 32 page booklet prepared by the American Society for Pharmacology and Experimental Therapeutics in cooperation with the country's major pharmaceutical companies. *A Career in Pharmacology* answers a raft of student queries, outlines pharmacological "firsts" and the basic areas of current research. Check No. 2241.

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INCO Magazine for January, 1959, is devoted to the "appearance" metals — chiefly stainless steel and the chromium-nickel steels. This publication of The International Nickel Company illustrates manufacturing processes and latest commercial adaptations (i.e., use of nickel in paint industry, palladium in jewelry-making), and gives information on silverware manufacture and electroplating. Check No. 2243.

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conquest of the thought barrier

Over the years, we have been hearing of many "barriers" in science . . . the sound barrier, the water barrier, the thermal barrier.

Of all the barriers, the hardest one to break through has always been the thought barrier. Every one of these "barriers" has been conquered by men to whom the word, impossible, means: "hasn't been done, *yet*."

The sound barrier is a shattered concept, as discredited as the phlogistic theory.

Don Campbell's *Bluebird* stopped all talk of the water barrier.

The heat of air friction against the metal "skin" of an airplane was supposed to create a heat barrier at Mach 3. Materials now in production can safely withstand the much higher temperatures involved in flight at Mach 5.

Today the thermal barrier is being called the "thermal thicket"—evidence in itself that no barrier exists.

An interesting point that all of these "barriers" have in common: each was conquered with the help of nickel-containing alloys.

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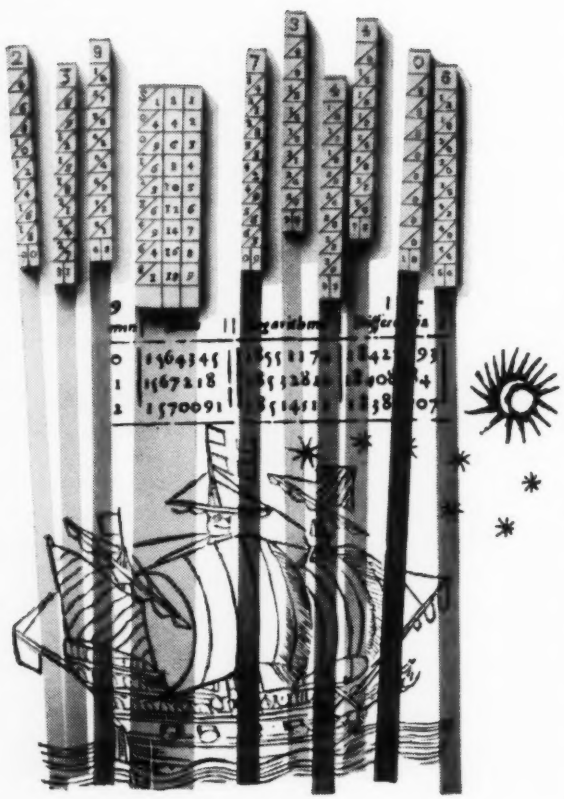

MAGIC NUMBERS: For years, in the brooding manor house overlooking a little Scotch village, John Napier worked in mysterious seclusion. Some of his 16th century neighbors even suggested that he was dabbling in witchcraft. But there was no black magic about the ivory calculating "Bones" he invented to help merchants figure their accounts. And it was pure genius that enabled Napier to invent logarithms. With these magical numbers, the most complicated multiplication and division could be quickly transformed into easy addition and subtraction. Logarithms halved the labors of star-charting astronomers; made calculation so easy that unschooled mariners could quickly plot their position anywhere on the seven seas. Today our cities, highways, dams are built on the logarithms that speed engineers through the thousands of computations each design requires.

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Some tips on trips
(Continued from p. 1-T)

leading to the understanding that different micro-organisms might be involved and that, by providing certain environmental conditions, we may produce either pollution or purification. "Where can we see such environmental conditions provided?"

Most large institutions have pamphlets or other printed materials relating to their work. If possible, obtain copies for your class and distribute them in advance of the trip. If it is the application of principles students are going to see, review the principles. Show pictures, diagrams, or charts that may help make more meaningful what they are going to see. Assign questions to direct attention — but do not overdo this. (There is nothing more deadly than a class spending its time answering the teacher's questions when they should be observing what they came to see.) Assign titles of special reports to volunteers and suggest or elicit an outline for the report that is required from each member of the class.

Follow through when students return to class. Give students an opportunity to raise questions about what they have seen. Have the class listen to and discuss special reports. Stimulate and encourage outcome — experiments, demonstrations, exhibits, and projects.

Evaluate the trip. Was it less than successful? If so, what went wrong? Was the place unsuitable? Were arrangements poor? Were the students unprepared? Did you get parent complaints? If so, re-read this article. Or, was the trip successful? If so, extend the opportunity to your next year's classes. Trips, like lessons, tend to get better and better when conscientiously repeated. — ZACHARIAH SUBARSKY

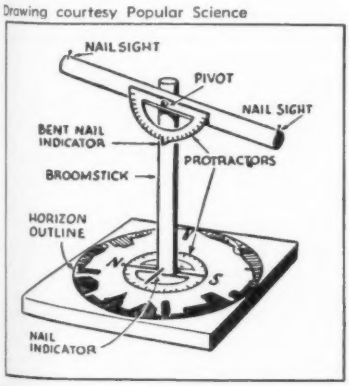
How to do it

Making a star finder

Though astronomy is a standard part of earth science and general science courses, it is difficult for classes to assemble at night to observe the stars. So individual students must usually make their own observations at home. The homemade star finder shown can be very useful for this. It is made from a wooden base, two pieces of broomstick, and three ten-cent protractors.

The base is a piece of wood about 1 inch thick and about 10 inches square (the wooden end of an apple or fruit box will do). The first step is to paste a paper circle of about 8 inches in diameter on the wooden base. On this the student marks the directions North and South and traces an outline of the horizon in all directions, as seen from his own point of observation at home. Then he proceeds as follows:

Drawing courtesy Popular Science



With tacks, fasten the protractors base to base in the circle, as shown. Cut two pieces of broomstick, each 12 inches long. Drive a 2 1/2-inch nail through the center of the base into one piece of broomstick, so that it stands vertically. A nail driven into this piece of broomstick near its bottom end serves as an indicator. Now drive nails near each end of the second broomstick section, as shown. These are sights. To the center of the same stick, cement a protractor, as indicated. Then drill a 1/8-inch hole through the middle of the stick, pass a 1 3/4-inch wood screw through it, and screw it to the vertical piece. Add a bent nail, as an indicator for the upper protractor.

Sight the star finder on a constellation or a bright star. Then note the elevation and azimuth (horizontal position). By checking this location on a star chart of the appropriate season, the constellation or star can be identified.

The instrument can also be used in reverse. Set it for the position of a star as indicated on a star chart. Look along the sights to see the star in the sky. Since the stars move, it is a good idea to use a chart that has corrections for the hourly positions.

All students might be asked to make their observations at the same time at home. Position information could be supplied in advance by the teacher or by a student amateur astronomer.

MEMO FROM IBM

The invention of logarithms so shortened the labors of astronomers, a great mathematician once declared that their lives were effectively doubled. Over the past three and a half centuries this has been true not only for astronomers but for men in all scientific fields. It is questionable whether either the mathematics or the engineering of today could have developed without logarithms. The Scots laird to whom we owe this magnificent discovery was a contemporary and kinsman of that fierce Earl of Bothwell who carried off Mary Queen of Scots. But the savage feuds of sixteenth-century Scotland played small part in the life of John Napier, Baron Merchiston. He was a scholar, an outspoken theologian, an ingenious inventor.

Napier's practical inventiveness was shown in the little bundles of numbered sticks called "Napier's bones." Each stick was in effect a multiplication table for one digit. To solve a multiplication problem, the sticks were lined up in order and the answer found by reading across at the proper level. The bones were essentially an ingenious gadget. It was when he turned to mathematical theory that Napier's great imaginative insight was revealed.

Sixteenth-century astronomers were struggling to compute tables of trigonometric functions for use in finding star positions. Napier's interest was aroused. The slim volume that eventually resulted in 1614—*Mirifici Logarithmorum Canonis Descriptio*, or "A description of an admirable table of logarithms"—was a milestone in mathematics. In making it easy to figure trigonometric functions, Napier vastly simplified all mathematical calculation.

Quickly recognized as a valuable invention, logarithmic tables were calculated for thousands of numbers and carried out to many decimal places. The invention of the slide rule—the "slip stick" of every engineer—made logs even more useful in our expanding technology. Engineers and scientists still use logarithms a thousand times a day, although very recently calculators and computers have taken over some of the tasks for which logarithms were formerly used. No machine can replace the genius of a Napier, however, nor rob him of his renown.

Advertisement)

Shop talk

J. H. Stoner, science teacher at Bad Axe (Mich.) High School, writes:

Would you like the slower students in your class to feel a measure of success and satisfaction in chemistry? Would you like the entire student body to see what you are doing in chemistry class? Would you like parents to see what you are doing in chemistry class? Would you like your students to have a lasting and accurate impression of the inside of an atom? When studying the unit on "Atomic Structure," would you like to have an activity that compensates for the lack of laboratory experiments on that topic? If your answer to any of the above questions is yes, try having your students build atomic models.

As a substitute for lab experiments in "Atomic Structure," I ask each student to construct a model of some atom. Students are given six weeks to complete their models. Each model must be built outside of class. Twenty-five per cent of the student's six-week grade depends on the model. Students may use any materials that are available. The finished model must be less than nine inches in diameter (so as to fit into the hall showcase). Three-dimensional models count more than two-dimensional models.

Each year, I ask to keep the best models to show as samples to next year's class. Result? Each year the models get better. We display these models in the hall showcase, where they are sure to attract the attention of other students. Teachers see them, also. Parents view them at open house.

Chemistry students, while building them, obtain a lasting impression of the make-up of an atom. Quite often, one of the slower students (academically) produces one of the best atoms; and for a short time he gains the admiration of his fellow students. He experiences success, and, with success, a better liking for the subject.

The atomic models are varied as to size and complexity. So far, the simplest atomic model brought in has been the hydrogen atom. This year, one boy made models of the three isotopes of hydrogen. The most complex model has been the uranium atom. The smallest model has been 3/4 inch in diameter (enclosed in a cufflink box). See Fig. 1.

The largest model built was three feet in diameter. See Fig. 2.

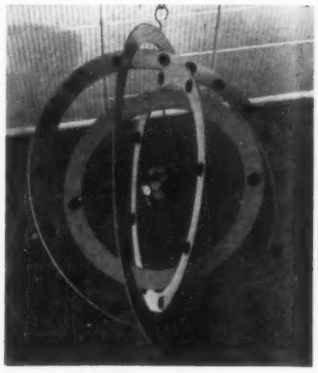
Most of the models have been built along a simple concept of the atom: nucleus consisting of neutrons and protons, plus orbits holding electrons. Talented students, however, try to incorporate newer concepts of its structure. At present, I have about 75 atomic models waiting to be shown at open house.

As with any other project, one learns from experience. The first year that I suggested building models of atoms, I gave the students free rein. There was no limit on the size of the model. As a result I received a pleasant surprise.

At the close of the period on the day when the project of atomic models was explained to the class, one of the boys came to the front of the room to my desk. He asked how large the models could be. I answered, "Any size." He asked if he could build one three feet in diameter. Thinking that he was joking, I replied, "If you build a model that is three feet in diameter, I will personally hang it from the laboratory ceiling." He left, but on the deadline day walked into the room with a large, flat object. When the object was opened, it became a beautiful model of a copper atom — three feet in diameter, with circular plywood orbits that could be rotated to any position to give a three-dimensional effect. There was a soft-ball nucleus, electrons made of painted pop-bottle caps, neutrons and protons made of corks from inside the pop-bottle caps. From the bottom of the model hung a plywood disk, upon which was placed a key to the identity of the different parts of the atom. And at the top of the model was a ring — to suspend it from the ceiling. I lost no time in finding the custodian, who fastened a hook in our lab ceiling. We hung the atom from the ceiling; and there it hangs today, to give beginning chemistry students a better concept of our unseen friend the atom.

Fig. 1

Fig. 2



Someone has said that a person's concept of the atom will never be complete. We will never know all there is to know about the atom. Knowledge is infinite, and our concept of atomic structure will merely expand and grow more complex with study. Eventually we may find that a true concept of the atom cannot be shown by a model, but it may be much easier to visualize and comprehend if we start with a visual model. Building atomic models first will better insure the enlarged and deeper concept of atomic structure later on.

Twenty-five dollars will be paid for material used in "Shop Talk." The editors regret that they cannot acknowledge or return unused contributions. Send to: Science World Shop Talk, 575 Madison Avenue, New York 22, N.Y.

MATERIALS THAT CAN BE USED TO MAKE ATOMIC MODELS

Nucleus	Orbits	Electrons, Protons, Neutrons
Ping-pong ball	Model airplane wire	Carpet tacks (painted)
Cork fishing floater	Pipe cleaners	Thumbtacks (painted)
Sponge rubber ball	Coat-hanger wire	Lead BB's
Spherical piece of styrofoam	Cardboard rings	Copper-coated BB's
Ball of clay	Iron wire	Small glass beads
"Mass" of BB's glued together	Plywood rings	Small spheres of styrofoam
		Holes punched in cardboard ring
		Small candies
		Balls of clay
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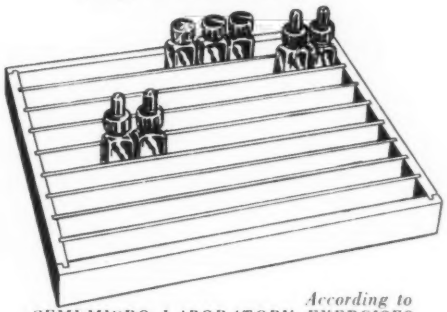

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Memo to teachers – "Conquering the thought barrier"

"Theoretically possible — but practical considerations, you know, prevent us from . . ." how often that phrase has meant a polite refusal to use *today's* scientific tools in tackling our fascinating unsolved problems. Such problems as unfailing power sources for space craft, or dependable passenger-carrying intercontinental rockets.

We have some good tools to help us right now. The basic tool is — a curious man. He may wonder, for instance, why sound travels at different speeds in air (750 mph at sea level, or Mach 1) and in iron (11,600 mph). Or how fast he can shoot an object through the atmosphere — a modern rifle bullet can move at 1800 mph.

He may have been told that a boat can't be pushed faster than 200 mph through the water, or that an airplane will rip apart if pushed over the 750 mph sonic speed "barrier" . . . or will melt at speeds over 2100 mph — Mach 3. But curious men like scientists score dramatic successes over such "thought barriers" with the help of a scientific thought pattern. It goes like this —

(1) Observation of the problem, followed by a concise statement of what answer is wanted.

(2) Gathering all available pertinent information — experimentally, if need be.

(3) Relating this information with a theory.

(4) Checking theory — experimentally, or by some other unbiased method, to see if it accords with observations. If not, seeking further observations, refining or changing theory, and so on, until theory and facts coincide.

And so, the curious men put science to work — as in 1957, when Bluebird K-7 scuttled old notions of water drag by doing 239.07 mph. Or, they use their findings to push through other "barriers" — and fly man-carrying rocket planes at 4000 mph, using a Nickel alloy skin to withstand the 1000°F. frictional heating.

Penetration of "thought barriers" is the rule in a course taught at a famous Boston institute — where students consider another planet's inhabitants — beings who move on two-hoofed feet, who have three eyes, and only three fingers. Students are asked to design usable transportation, communication, housing, and food-producing facilities for this planet. This unusual approach to the scientific way of thinking frees young minds from earthly, conventional problem-solving.

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$$SiO_2 + Na_2O + CaO + MgO + Al_2O_3 \xrightarrow{\text{◇D}} \$$$

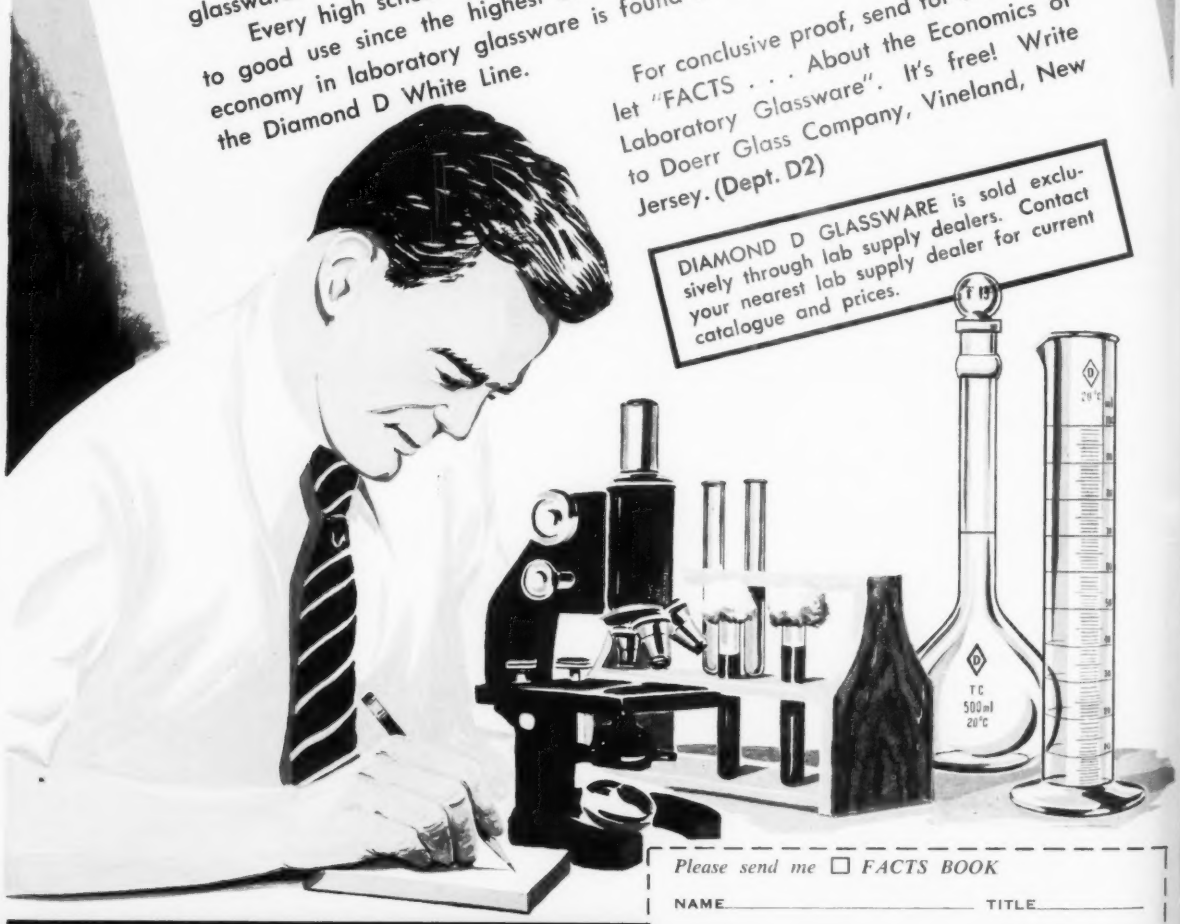
In the formula above, the Diamond D glassware symbol is shown in catalytic reaction with the constituents of high grade lime glass to produce dollars saved.

Technically, the formula may be far-fetched, but, in a practical sense, it is a means of insuring maximum economy in the purchase of laboratory glassware.

Every high school and college science laboratory can put the formula to good use since the highest combination of top quality and maximum economy in laboratory glassware is found in the Diamond D Blue Line and the Diamond D White Line.

For conclusive proof, send for our booklet "FACTS . . . About the Economics of Laboratory Glassware". It's free! Write to Doerr Glass Company, Vineland, New Jersey. (Dept. D2)

DIAMOND D GLASSWARE is sold exclusively through lab supply dealers. Contact your nearest lab supply dealer for current catalogue and prices.



Please send me ☐ *FACTS BOOK*

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DIAMOND "D" GLASSWARE

Quality Begins With Price And Ends With Performance